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NORTH ATLANTIC TREATY ORGANIZATION

RESEARCH AND TECHNOLOGY ORGANIZATION

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RTO AGARDograph 338

Kingdom in the Sky – Earthly Fetters and Heavenly Freedoms. The Pilot's Approach to the Military Flight Environment

(le Royaume au ciel – Fers terrestres et libertés célestes. La démarche du pilote vis à vis de l'environnement aéronautique opérationnel)

This AGARDograph has been sponsored by the Human Factors and Medicine Panel (HFM) of RTO.

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Kingdom in the Sky – Earthly Fetters and Heavenly Freedoms. The Pilot's Approach to the Military Flight Environment

(RTO AG-338)

Executive Summary

This book provides insight into the psychology of the Russian flyer. While working under extremely difficult conditions, the flyer continues to do the best job possible out of a sheer love of flight. The book focuses on the flyer, considered by the author as either the pilot or other aircrew members, and the flyer's constant struggle to overcome the procedures dictated by ground-based directors while enjoying the thrill and emotional high of flight. While describing these freedoms of flight, the author takes the reader through all the turmoil and travail of in flight emergencies, unpopular ground-directed missions, and, ultimately, aircraft mishaps resulting in the loss of lives. It describes through detailed studies and interviews the difficult conditions placed upon the flyers because of a system inadequately prepared to address known human factor issues. Dr Ponomarenko points out that all too often the flyers are blamed for problems beyond their control, but they deal with these problems in a way that reflects upon the basic character of all flyers – a character that is almost spiritual (their human spirit). He also reminds the reader that it is the responsibility of those on the ground to improve the conditions of the flyer. Those improvements can come from the knowledge learned from detailed studies and the appreciation for the flyers' mission.

The prologue sets the stage. It is an overview of the book and, at the same time, a testament of Dr Ponomarenko's ability to reach beyond the grasp of the usual flight doctor. Chapter 1 provides details of the problems associated with aircraft accident investigations and the impact these investigations have on the flyer's dignity. Chapter 2 describes many of the dangers associated with flight, as well as the skills necessary to overcome those hazards. Chapter 3 is an excellent description of the current state of human factor issues and flight safety. Data are presented to support the author's claims. Chapter 4 goes into an interesting explanation of ergonomics and its relationship to flight safety. It is interesting to note the similarity with Russian ergonomic problems and the same types of problems encountered throughout the world. Chapter 5 matches the role of the flight doctor with the operational requirements of the flyers. Chapter 6 identifies the problems encountered when one is too conservative toward a profession that requires radical, rapid, and sometimes fatal in flight decisions. Chapter 7 explains to the flyer how to maintain a healthy body – both physically and mentally. Chapter 8 concludes with an uncommon insight into the flyer's soul. The chapter is an excellent summary of all the research, reports, and lessons learned during Dr Ponomarenko's life while working with the flyer and within the establishment. His frustration shows, yet his love for the flyer comes through loud and clear.

le Royaume au ciel – Fers terrestres et libertés célestes. La démarche du pilote vis à vis de l'environnement aéronautique opérationnel

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Synthèse

Cet ouvrage donne un aperçu de la psychologie de l'aviateur russe. Tout en travaillant dans des conditions extrêmement difficiles, l'aviateur continue de fournir la meilleure prestation possible, animé par un véritable sentiment d'amour pour le vol. Le livre privilégie l'aviateur, qui peut être pour l'auteur soit le pilote, soit les autres membres de l'équipage, et met en lumière sa lutte constante pour surmonter les procédures dictées par les contrôleurs au sol, tout en profitant des frissons et de l'exaltation qui accompagnent le pilotage d'un aéronef. L'auteur décrit ces libertés, et en même temps renseigne le lecteur sur les bouleversements et l'angoisse éprouvés lors des situations critiques en vol, ainsi que sur les missions malaisées commandées du sol, et, enfin, sur les accidents d'avion ayant pour conséquence la perte de vies humaines. Il décrit, par le biais d'études détaillées et d'entretiens, les conditions difficiles que les aviateurs doivent supporter, en raison du fait que les systèmes sont mal adaptés à l'être humain. Le Dr Ponomarenko fait remarquer que trop souvent, les pilotes sont mis en cause suite à des événements qui sont indépendants de leur volonté, mais que la façon dont ils tentent de résoudre ces problèmes reflète bien le tempérament fondamental de l'aviateur, tempérament qui est presque spirituel (leur esprit humain). De la même façon, il rappelle au lecteur qu'il y va de la responsabilité du personnel au sol de faire en sorte que les conditions de travail du pilote soient améliorées. Ces améliorations dépendent des connaissances acquises lors de la réalisation d'études détaillées et du respect de la mission du pilote.

Le prologue pose le décor. Il donne un aperçu du livre qui témoigne en même temps de la capacité du Dr Ponomarenko de saisir des éléments qui ne sont pas à la portée de la majorité des médecins de l'air. Le chapitre 1 donne le détail des problèmes associés aux enquêtes sur les accidents d'aéronefs et l'incidence de ces enquêtes sur le mental des pilotes. Chapitre 2 décrit les dangers associés au vol, ainsi que les techniques permettant de s'affranchir de ces risques. Le chapitre 3 donne une description très complète de l'état actuel des connaissances dans le domaine des facteurs humains et de la sécurité des vols. Des données sont présentées pour étayer les affirmations de l'auteur. Le chapitre 4 présente un exposé très intéressant de l'ergonomie et son rapport avec la sécurité des vols. Les parallèles qui existent entre les problèmes ergonomiques rencontrés par les russes et les mêmes types de problèmes rencontrés dans le monde entier sont à noter. Au chapitre 5, le rôle du médecin de l'air est confronté aux besoins opérationnels des pilotes. Le chapitre 6 identifie les problèmes soulevés par une approche trop conservatrice d'une profession qui exige la prise rapide de décisions radicales en vol, qui ont parfois des conséquences fatales. Le chapitre 7 explique au pilote comment mener une vie saine tant mentalement que physiquement. Le chapitre 8 conclut par un aperçu peu commun de l'âme du pilote. Ce chapitre fournit un admirable résumé de l'ensemble des recherches effectués, des rapports publiés et des enseignements tirés par le Dr Ponomarenko au sujet des pilotes pendant sa longue carrière. Sa frustration est évidente, mais aussi l'amour qu'il porte au pilote, qui est reçu cinq sur cinq.

Contents

To the officers of the Russian Scientific-Research and Testing Institute of Aviation and Space Medicine the author dedicates this book.

FOREWORD

Vsevolod Ovcharov,
Candidate of Science (Aviation Technology),
First Class Test Pilot, Colonel (Ret).

The work of the flyer is to some extent, irrational in nature. It consists of a complex combination of knowledge in intuition, of volitional acts, and spontaneous decisions of intellectual and physical work. The flyer may or may not be intelligent, generous or thrifty, clever or not clever. This may all be true until the time of a forthcoming mission. I have witnessed prompt in-flight reactions in sluggish thinkers: I observed events of selfishness, which were difficult to foresee on the ground, in subjects notorious for their egocentric highly pragmatic attitudes.

I have sometimes criticised the author for idealising the flyer. Some years have passed since my last landing, when I embraced for the last time my aircraft and kissed its armoured cheekbone. Now I am retracting my criticism – the flyer is a man of the highest order... V.A. Ponomarenko has understood this, in greater depth than I have, and his book relates all about it.

There is no uniformity style, content, and spirit in this book. The reader will see the proofs and an invocation hymn to the aviator, and a belittling of those who don't see in aviation its essence. In details of abstract reasoning, and of accurate quantitative investigations, he attempts, and in my opinion, succeeds to create a unity by combining all physical and psychological limitations of the spirit.

The motif of the book, which covers a great variety of data, contains two main thoughts: 1) the profession of the flyer (more dangerous than that of the most dangerous profession) demands inner freedom and those qualities which give freedom; and 2) those who determine the strategy and plan a life in aviation (including instructors and commanders) should proceed from this first and main premise.

This is not a call for anarchy. What I said about the qualities assuring an inner freedom, include first of all, professionalism in all its manifestations, as well as psycho-physiological personality traits related to performance, knowledge, skills, and sound habits. This is what gives a pilot the right and obligation to use all the capability of his aircraft when necessary, as in special flight situations, in non-standard environments, or in combat.

The main requirement of civil and military aviation in peacetime is flying safety. This requirement is controversial, since any flying activity presumes practically the maximum use of the equipment, i.e. profitable and "on-time" transportation in civil aviation and maximum combat efficiency in military aviation. Moreover, to assure flying safety, one needs to consider the reliability of the technology. Reliability of technology means a decreased risk level will lessen the useful output of the equipment at the expense of physically unsubstantiated limitations of the operational conditions. The single way to sell this controversy is to reject the technology standard approach in favour of a man centred or an anthropocentric approach. In my opinion, this is confirmed by the impressive achievements of the American space program by recruiting astronauts among experienced test-pilots, at the time in their early training, which allowed the use of simulation to insure astronaut performance, but not to replace him.

This book addresses a variety of anthropocentric approaches, and is to aviation as monograph manuals, technical reports, lectures, and oral presentations are to the author's students and followers of his teachings.

The disciples of this school are many – ground crews, cosmonauts, military and civilian pilots, engineers, and physicians, even (secretly) many aviation commanders and top instructors. The representatives of the last two categories did not subtly convert anthropocentrism, this happened thanks to the soundness of theories, and argumentatives, talent, energy, and uncompromise (frequently at personal loss) of the school founder: the author of this book. The monograph you're just beginning to read actually consolidates all that was worked out by the author (his colleagues and pupils) in the areas of physiology, psychology, psychophysiology, and specialised fields in aviation medicine. The data presented are often unique. Sometimes they are even shocking. After a

flying career of 50 years it seems that government "deafness" to aviation problems is a great error, when about half the flying military personnel is grounded five to seven years due to hardships of work conditions, service and social environment. Under the current socio-political conditions, 80% of the instructor pilots are former mediocre cadets, 40% do not like their tutorial duties, and 70% do not have any didactic inclinations. Yet they are the flying instructors. How can we speak of successful flying activity, if only 5 to 10% have marked flying abilities, whereas a potential ace, which could become the pride of the aviation and country, did not enrol in aviation due to various causes?

At times I feel the tide of hope and pride for our scientists, colleagues, and co-workers, when I read about major improvements in the sophistication of technology, implemented through laborious efforts, but mainly, through systematic theoretical and experimental studies.

The book includes:

- fundamental and applied flying safety research;
- psychological and didactic problems of man's safety;
- problems of scientific and ergonomic supervision of research in development, testing and operation of aviation technology;
- problems of timely strategically directed prophylaxis of dangerous flight factors;
- health problems and socio-psychological flying safety factors and many others.

I feel compelled to cite all the issues discussed in the book. The issues are all important to the flying profession – selection and training, non-traditional approaches to find the cause of aviation accidents by evaluating aircrew activity, problems of organisation and direction from flight surgeon activity, as well as special training (psychological, physical, and occupational) of aircrew on new aircraft in extremely difficult flight conditions, and problems of ergonomic design of the aircrew cockpit, and, finally, spirituality of the flying profession. The book is permeated with profound love for aviation and the aviator. And this love has its sources. A world-renowned scientist, he has lectured authorities of the USAF and Russian Air Force. He is a leader whose opinion impacts high-ranking officials of the Armed Forces and their deputy's decisions, a specialist whose concepts and proposals are implemented into hardware and manufacturing of the world's best fighter aircraft. This man started his career in aviation as a young Wing flight surgeon, and learned there to handle a fighter plane. That unexplainable magic of flying, which is simply described as space perception and control of one's movement in space, instantly took him over forever. He later said that he learned to fly, in order to understand as fully as possible the essence of flying and the life of his experimental subjects and patients. I believe that passion for flying represents envy of such vanity which the pilot experiences just before flying and right after the mission, which gives him (her) a circle of closeness to colleagues. He has been penetrating the flying mystery. Moreover his sharp and paradoxical scientific mind prompted him to solve this mystery, and he has solved it. Being a scientist and a flyer, he rationalised what the pilot frequently, only vaguely, perceives, or hides behind an armour of irony. The author gives explanation to those who want to understand. But unfortunately not all want to comprehend this. I guess that striving to disclose the mystery was one of the compelling motives, which led Ponomarenko to choose aerospace medicine. This is a field in which he climbed the traditional steps of a scientific career – candidate and doctor of sciences, and later he also consolidated the investigation of problems related to "man in aviation". He broadened the concept of common motions and created a new concept of man as the system-generating point in aviation technology from creation and evolution to functional failure.

Yes, the author has reached the pinnacle of his career: he is an academician, a professor, a doctor of medicine, a prize-winner, and a general – awarded many medals. Presently, all these awards might even compromise him. But his case is special. All was obtained not in compliance to the system, but in defiance of it by principled attitudes, conceptual substantiation, disputability ideas, ponder of arguments, uncompromised moral position, and to be sure, by titanic work. This book cannot be classified to a definite genre. Some of it is lyrical, and some is physics.

I read and re-read this and other books by Vladimir Ponomarenko, and one thought depresses me: why is it that all he writes is not accepted by those who depend upon the life of aviation and the life in aviation? I am inspired by the fact that, just as droplets, little by little, the ideas of the author have emerged. The droplet grinds the stone – gutta cavat lapidem. I hope I will live to see the triumph of his concepts.

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Prologue

"In aviation cowards are not chided they are washed out"
Captain S.S. Ivanov, First Class Air Force Pilot

The dwellers, i.e., the flyers, are the bearers of the human spirit. They are life-loving, simple, cheerful, warm hearted people, and have an excellent sense of humour. They are self-controlled, patient and possess a great stamina, are capable to endure life's blows and to react to all types of life's situations. This is not idealisation and iconisation of the profession. This is the image, which the soul maintains about life experienced and lived in an aviation command. However, the strategic aim of the book compels me to tell about the Achilles' heel of aircrews flying safety psychology and, even more so the destiny and life of man in this dangerous profession. The philosophy of this psychological problem consists in the fact that more than 100 individuals support one pilot in flying safety as a social phenomenon, without including the aircrew in this psychological problem. The attitude of the 'superiors' managing flying safety is service guided – do not admit danger; while the aircrew has its own operational aim – overcome the emerging threat to their life. In other words the aircrew estimates the seriousness of the danger based on a concrete threat. There might be a small difference in opinions but in real life, it sometimes becomes a 'knot' of inconsistencies despite the will of the flyer. And the most insulting is the fact that, though the 'knot' is based on one set of rules, the flyer must untie and loosen with another set of rules.

Presumption of guilt starts when rules and a succession of events during a complicated flight dictate a strict sequence of actions, and the psychological essence of the emergency frequently changes the performance. Moreover, there are no laws regulating the situations, they are just a matter of fate. This represents the psychological drama of the aircrew – the operational evaluation of the actual degree of flight danger frequently does not coincide with the legal one. The difference in the interpretation is due to the fact that the aircrew operates in another space and time. The performance of instructions in a given urgency situations is tactical. Behavioural strategy is determined by concrete psychic reaction to time in space awareness. In other words, one of the typical errors in an emergency situation is incorrect time perception. Decisions and performance are personal manifestations. The flyer's strongly sense that flying safety is achieved through danger (M. Gallay), and it is officially recognised that the less the danger, the greater the safety. The flyer's daily life is well protected by legal norms, government standards, flight operation and regulations, etc. and only in an occupational situation, as flying emergency, is he helpless. Our aviation literature does not discuss the problem of the right of life in emergency occupations. In the flying occupation most administrators want only to command, only a few accept responsibility. For example, the decision to land aircraft with wheels up or without engine thrust, but not to eject above a residential area, proceeds from the right of life. Thus one is psychologically justified to assert that the flyer's right to life is his personal moral property! Similarly, the establishment of the moral limits of this 'property' is influenced by professional and personal maturity. The latter is included in the understanding of aviation community responsibility, i.e., by those who guarantee flying safety. The following episode serves as example (pilot, Russian hero, V. Gorbunov):

> "Gorbunov was on a sortie to test the stability and controllability characteristics of a test aircraft built by Special Design Bureau named after A.I. Miloyan. The aileron control suddenly broke. The ailerons move smoothly causing left banking. By only pushing the control stick and pedals to the right does the aircraft maintained a straight and level flight.
>
> Gorbunov decided to land his aircraft on an airfield. With great effort he recovered from a role and maintained glideslope and began to descend. At an altitude of about 30 meters above the ground level, just before flare-out, there was a strong swing in role axis of steering – Gorbunov warded it off and stopped the descent. All extreme movements of the control stick to the right could not correct the banking and the ailerons spontaneous deflection. He gave full throttle in trying to climb. The aircraft started to move above the runway with an increasing left banking (up to 45 degrees). A height of approximately 80-100 meters the planes nose dipped. Ejection became impossible, below were the base buildings and living quarters. Gorbunov instantly move the control stick to the banking side, this resulted in a normal attitude of aircraft. The control surfaces were fully deflected to the right side, and he reduced the after-burn thrust in

both engines, the left engine was on full rotation and the right engine on minimal. He performed repeated barrel rolls in order to align the required angle for climbing and takeoff. The aircraft rolled on a left trajectory and he avoided the residential area, then climbed and reached the unintended area. The manoeuvre was successful." (Magazine "Wings of Homeland", 1992, N9, p. 32; V. Selivanov).

Thus the flyer stands up for his right to life all alone in the sky. This example clearly illustrates that Gorbunov was limited to his own locomotor skills. If he had relied on automatism, his life would belong to Heaven! What an exceptional intellectual capability of moving the aircraft in space! After all, he actually turned upside down, and this deliberate action was the key to his salvation. The pilot distinctly saw and mentally steered the space, which was possible only through his own personal evaluation of the events (crisis).

Regrettably, figuratively speaking, today one esteems more a "yes sir" pilot "trimmer", than a pilot persona. At the same time one should admit that pilots (aircrew) usually respond positively to both fair and unfair reprimands. However, the ace flyer is 'spiritually' and feels deeply insulted when his motivations are misunderstood, especially when ground personnel cannot share his 'spiritual' need of air autonomy. Behavioural independence is the individual manifestation of the flyer's persona.

Thus the 'knot' of complex controversies is tied, which the flyer must untie in an emergency situation when alone in the sky. In practice, the aircrew is well founded and legally dependent on all his training for safety. However in an emergency situation the pilot is very reliable when he can be independent. Probably it was not by accident that Russian flyer Michael Gromov, founder of the Flying Testing Institute at Zhukovsky, fought for the right of the flyer to be creative and independent. He repeatedly stated that independent flying and thinking is a must.

Mandatory prerequisites for such independence are love of flying, professionalism, competency, good cultural lifestyle, and self-improvement as a human and a flyer. My life experience and research have convinced me that the psychological factor of independence stimulates creative individuality, a natural gift of the flyer, with high aims, and high morals. However, socially, the life-philosophy of flying safety has always been inflexible: individuality generates individualism, the positive role of which is very questionable. Frequently, in evaluating flying safety, we have all come up with opposite results. I have encountered this dilemma for the first time as the senior flight surgeon of the 382nd Air Defence Fighter Regiment. Since what follows concerns my personal experience and people who I trust with great value, I will attempt to be mostly exact. I will write about the social and psychological specifics, a flying safety time period covering about 30 years of aviation (1962-1992). In considering human states of the soul and conscience under routine and emergency flight conditions, I stumbled on a serious moral problem i.e., the proper meaning of the word truth in Air Force aviation. I write to the esteem of only those who are worthy of it, to recognise malingering hypocrisy, and bootlickers. Unfortunately, life and Air Force aviation in all its 'greatness' can frequently be a 'let down' because of deception, injustice, and power abuse. It would be naive and hasty to portray myself as a truth-seeker, a fighter for a 'pure sky', a defender of the rights for the flyer, etc. In aviation, truth is the runway, it may be short, long, illuminated, darkened, warm or ice coated. The truth is complex – it is objective and subjective, it is your pride in your shame. Truth is created in the history of the aircraft and the flyers. Therefore I will try to write only that which I saw with my own eyes, what I did eyewitness myself, and, more precisely, what I experienced as a participant. I will attempt to be honest and kind about my years in the Air Force, which is still carrying on and growing. I hope these words create in the flyers the special state of soul, which is called "flying". This reminds me of the Bible when God punished the serpent for trickery by forbidding it to fly. And this is not just a metaphor, but a painful conviction I have reached i.e., that "flying" is a specific spiritual state, invisibly supported by the space energy of living matter in the universe. More about this later. The different parts of my book will cover the history of my life in the Air Force. I am convinced that independence means the right of not being afraid of the pronoun "I". "I" in aviation means responsibility and honour. My reminiscences about service in regiment are not 'fiction', since they are directly related to the flying safety problem as a special cross of the flyer's life.

Despite my professional training in aviation medicine, upon my arriving at the regiment, I immediately fell my psychological incompetence: the inability to understand the flyer as a person who cannot be characterised only based on his heart rate. First of all, I was struck to realise that intellect, flying talent, and human nature does not depend on one's educational level. In mid '50s I was the only officer in the regiment with a higher education, but I lacked understanding of flying motivation. My first commander G. F. Panchenko, and later L.A. Pitersky, only expressed their thoughts figuratively, but were

also exemplary officers. Most of these flyers were veterans of the Great Patriotic War. In the wing, flyers and ground technical personnel were fanatically devoted to aviation. I learned that the climatic conditions of the geographic location of the regiment with its surrounding operational units, coupled with unsatisfactory radio navigational support and frequent high state of combat readiness, made flights unsafe. Nevertheless, flyers had been taking off even in fog, and this was considered especially 'smart' flying. The high-level of mastery and skill of the flyers completely neutralised the danger of the sorties. But we have experienced interactions seen in other flying aspects – the flying safety was deliberately placed on the shoulders of the departing flyer, while the shoulders of the leaders were soothed by the 'real environment'. Maybe, my impression might have been erroneous, but I was constantly haunted by the thought that takeoff on alert was much more important than the later safe landing, as mentioned to me by a second senior lieutenant S Kolesnikov.

Men in flight have been valued for their achievements, without taking into account the price they have paid. This was corroborated by tactical flying training, when, after a successful, extremely difficult 'enemy' intersection under cloudy night conditions, all hurried to the movie projection of 'shooting gun', showing the results of the interception. The flyer in his sweat soaked and worn garment patiently waited for either reprimand or encouragement. It seemed to me unfair, but the flyers did not feel any discomfort, they enjoyed the individual freedom in flight, where all, or almost all, depend on them alone. This represented a special flying pride. But at that time I had no clue what it was. It is noteworthy that 25 years later I observed the same situation while participating in a carrier landing flying safety study.

One of many successful MiG-29K landings on the carrier was performed by my test pilot T. Aubakirov. I ran with others to the aircraft to see a smiling pilot still sitting in cockpit. They thoroughly examined the aircraft, and were pleased that the plane sustained the impact acceleration. Later, at the ground control post, I became convinced that the more difficult the flying conditions, the more the unexpected events happen in-flight, and the more civil are the orders from the ground--the more one values the flyer's personality.

The sky always excites and inspires the flyer, but the earth frightens him. An emergency landing due to low fuel is neither an extraordinary event, nor a 'gift' for the flying safety 'piggy bank'. After a sortie, the pilots frequently landed with a critically low fuel, when the primary airport was unexpectedly closed due to fog, at a base runway under conditions of lower than permitted ceiling, minimum meteorological conditions and sometimes even lower than common sense would allow. But for the flyers of my wing it was not a special hardship when their aircraft stopped on the taxiway due to complete fuel expenditure, as long as the movie confirmed the target hit. It may be strange to say so, but such an unsafe policy generated in both flyers and commanders the need to 1) improve professionalism, and 2) improve the skill to recognise dangers not as a stressor, but a catalyst to mastery. The thoughts were never spoken, but the eyes of the flyers spoke for them. The first inkling of this psychology was the discovery that flyers communicated with each other intimately and honestly but not in a 'collectivist atmosphere'. They not only knew the price of their mission, but also humanely appreciated what each pilot had done fearlessly and alone in the sky.

On a distant countryside air base the flyers merged, and blossomed, unselfishness, goodness, good humour, and an understanding at comprehending the meaning of life. I was amazed by the cognitive activity of these people by their uncompromising right to creative solutions of tactical tasks used in the flying operational dynamics of the technical characteristics of the aircraft. On the initiative of most creative persons in the wing such as Captains P. Alatartsev, Yu. Proskuryakov, V. Surpin, M. Khodkevich, N.T. Tenitsky, S.S. Ivanov, K.V. Bichev, and Lieutenant Colonels V.F. Korolyov, V.P. Zubchenok, L.I. Morozov, V.A. Sidorov, procedures for the destruction of low speed high performance targets, the reconnaissance and scouting unmanned balloons, were developed. The same flyers, led by their commanders, worked out ways to increase takeoff speed, prolong non-stop missions, ability to land aircraft's after flameout, landing with faulty altitude and speed gauges during cloud penetration, night landing with headlights, squadron flight formations under poor weather conditions, interception at extremely low altitudes, etc. The flyers of our wing successfully transitioned to the new type aircraft, MiG-17F, MiG-19PM, not only without simulators, but even without flight operational manuals!

The flyers learned on mainly principles by word-of-mouth. The main result was a profound joy for discovering and acquiring new knowledge. Even the peers cannot conceive the pride felt by the flyers when they flew for the first time in the newly acquired aircraft. When an in-flight emergency occurred, each pilot considered it his duty to land the aircraft. One may say that life has no price, but for

the flyer life is too valuable and happy to simply give it up. We're not concerned with ideology but with something much deeper – belief in success or self-confidence. As a member of the flying community, the official responsible to enforce flying safety standards, I constantly faced problems of moral choice. And the most difficult choice concerned the balancing of the moral incentives which frequently conflicted with requirements of the flying rules.

February 1960. Due to whether conditions the runway had been closed for 30 days. Suddenly, the airfield is 'opened'. Deputy wing commander M.A. Nyrkov decided to permit sorties not only to the aircrew of the combat alert element but also pilot S.S. Ivanov. His duty was limited to night flying. This was a gross violation of flying safety rules. I was asked to approve the planned schedule and flights, but the flyer had not rested. There was no potential replacement. I examined the flyer and approved the sortie.

Serafimovich takes off in a MiG-29 (total flight time of this type of aircraft is 20 hours). During landing with low visibility the aircraft guidance controls breakdown. The flyer reports to ground control the emergency in encoded form. The chief controller in the tower, after a long silence, replied "Roger". Then again silence. On the neck of the controller I see drops of sweat. Suddenly I hear the crying of the enlisted ground observer: "Undercarriage is down". The pilot landed without incident and told his commander: "Excuse me, I nearly let you down". He was put in for an award, the commander and I, the senior flight surgeon, were reprimanded. Each of us accepted additional responsibilities, which was not covered by any paragraph and although we were all castigated, we were satisfied for a well-done job. Yes, complicated knots have been tied in the life of air defence aviation wings whose main responsibility was to protect the sky frontiers. Later, I began gradually to understand the causes of the fatal accidents in which some of my comrades were lost – they were unaware of their flying capabilities, or more precisely of their psycho-physiological reserves with regard to flying safety. In those days the flyer's reliability was, by all means, much greater than the reliability of aviation technology. Flyer reliability is the style of man's behaviour, his spirituality, and his dignity. We felt somewhat uneasy when the system of flying safety control generated, figuratively speaking, the "offences".

For example, a flyer is told to sortie under poor weather conditions, which forces him to prematurely abort his mission and return to the base. Those who ordered him to fly knew that the weather was not suited for landing. But while flying in the clouds the pilot optimistically reports (on tape recorder) that he sees the runway. He tries to justify the trust placed in him, but this could lead to a tragic outcome. The above relates to the so-called "unwritten laws" and there are a lot of them.

It is difficult to relate this too bravery, when elder comrades equate the risk of their welfare and carrier to the risk of the life of others. Another striking thing was a slogan about flying safety which was used to simplify the complex aspects of combat readiness even for first-class flyers. Moreover, un-ready 'aces' were assigned combat duty in most severe weather conditions. Yes, daily wing activity was not always subordinate to the commander. Too many bosses decided too many fates, and they did not bear responsibility for the life of Air Force Patriots. Yet, the love of flying was 'fanatic'. For me, as the senior flight surgeon, it was extremely stressful, since out of 52 flyers, 38 were first-class pilots, and 46 had serious diagnoses: sequelae of wartime. They need to be examined not only clinically, but also for their flying qualification. I repeatedly requested that Defence Minister R.Ya. Malinovsky, through the regional Air Defence Commander, and obtained permission to fly on the aircraft trainer MiG-15 in combat readiness missions. From this moment I started the true, not the book, learning of the pilot persona in the meaning of his profession. Flight instructor V.Ye. Ivanov, the wing deputy commander, and squadron leaders, all gladly welcomed me, and each demonstrated the capabilities of the aircraft and their own. I was able to observe the character, the manners, and habits, the level of teaching skills of 'my' flyers. Of course some rules were side-stepped. But maintaining the performance of my 'sick' flyers was excellent and their arterial pressure and heart rate were more stable in flight than in pre-flight examinations. This all led to a spatial feeling of reciprocal confidence and to the determination (consideration) of flying workload standards. Numerous in-flight psychological investigations were performed, but they will not be discussed here. In flight, the pilot has been recognised as human. I wish to stress here, that a successful in-flight emergency depends not so much on his automated actions but on his intellectual abilities. In the past, the term 'intellect' was used predominantly in a sarcastic sense. My observations gave me the objective proof that mind and spirit have the leading role in the flyer's performances. Spatial orientation, information processing, decision taking, risk strategy of performance in emergency are all determined by his intellect, and his conscience helps his brothers in heaven. The flyer's performance is basically individual, but the persona of the flyer, as

well as that of the entire aircrew depends on the flying community. They share a single 'spiritual field'. Flying determines the spiritual affinity, and the latter, in turn, evokes the feeling of satisfaction. In fact, combat sorties consist of two aircraft. Wing-to-wing is a sacred aviation love. Love of flying represents protection from the danger, a condition for creativity. It is a pity that then as now many high-ranking generals think that creativity in flight is chimera, sense in the air the 'good boys' do not create, but act as 'fools'. However in the spirit of creativity, the love of flying, respect for creativity reigned among elements and squadron leaders in my beloved wing. I was convinced of this once more by observing the test flight by commanders Vasiliy Gavrilovich Ivanov, Alexander Vasilyevich Fedotov, Valentin Petrovich Vasin, and Alexander Savvich Bezhevets. They were all recipients of the title "Hero of the Soviet Union", but their main deed was that they were faithful and true to their subordinate flyers. Then, as now, I am proud of the fact that the commander in an aviation community is first of all the authority in the sky and on earth. The spiritual climate in my wing allowed for unity and innovation. "Do as I do", is only a partial technique used by the commander who taught us to act according to our conscience, to love, to reason, and not to harm others. This is a moral angle of attack, which supports the flyer and will not allow him to fall down in the true meaning of the word. The commander is always our soul, but not someone to 'piggyback' on, he does not impose his ideas, but he arouses patriotism. The spiritual influence on the flyer does not consist of preaching love of heaven, but by example of his own love. I feel no embarrassment in writing these lines, since I am setting forth the actual truth about my commanders. The flyers of my wing had a roof over their head, and the name of that 'roof' was – Commander.

Allow me to cite an example of an unusual decision taken by a pilot who saved the prestige of the former USSR. But this decision could have cost dearly without a 'roof' over his head. He knew the consequences for his decision taken with the wing deputy commander L. I. Morozov against orders and rules. This concerns an incident which happened on our airfield in 1961. At 5:30 a.m. the Air Defence Command centre gave the order to intercept in aircraft. For unknown reasons the aircraft of the potential foe had not been stopped and continued to fly. Captain I. Chumakov had received the order from a ground tracking station "Detect and destroy the target". Chumakov rapidly intercepted the aircraft which was a Caravelle, a commercial plane. Then another plane joined him. It was pilot N. Lebyodushkin, on a MiG-19. He came so close to the target aircraft that he could recognise passenger and children's faces in the windows. Following the orders of L. Morozov, both pilots began to accompany the aircraft for landing, but did not shoot it down as ordered. The weather in the meantime deteriorated, they manoeuvred the "Caravelle" to the landing approach. They pierced the first cloud ceiling somewhere around the middle radio beacon, and then the "Caravelle" began banking at more than 30 degrees. Witnesses recall the scene with horror. Both fighter planes circled and the "Caravelle" landed successfully on the runway. Our fighter pilot, landed second, using the braking parachute suddenly stopped on the taxiway due to empty fuel tanks. Minutes later pilot I Chumakov also landed with empty fuel tanks. Pilot I. Chumakov had deliberately ignored the order to shoot down the trespassing aircraft and had refused to use the on-board weapon system, risking losing his career and even his life. It was a fact, and all the wing pilots approved his conduct [independent decision]. The flyer should curb evil duties required from him, even at the expense of someone's life. But his soul does not allow him to be a 'criminal'. In an operational regiment the flyers taught me to understand the meaning [essence, import] of their profession. They nurtured my love of sky and aviation, they guided my scientific thinking and, to defend my principals, they brought me to recognise a shining soul and path leading to the truth. In this connection I wish to share another occupation concerning the teaching of pilots and aviation flight surgeons. In the military community most are not to fond of aviation medicine, and they ask rhetorically: why is there not 'tank medicine'.

In the Air Force, the flight surgeon is a confessor who listens to the flying doubts, personal problems, his fears and hopes for a long prolonged and happy life in the sky. All this requires purity of thought, self-confidence and honesty. If such a climate exists in the flying community, it is attributable to the flight surgeon. The general practitioner may become a highly qualified physician, but he will never be a fight surgeon, for he may be 'born' only in his own wing. If the aviation spirit is lacking in the wing, they will never have a good flight surgeon.

In aviation, physicians combine all sorrows and joys of the flyers. He establishes the broader communication with commanders, families, clinical consultation expertise, special services, in other words with all who influence the fate of the flying crews. From my favourite 382nd defence wing, many became experienced and renowned aviation medicine specialists. We have lived and worked in a socialist society, but anyone of "humble fools", called in

Russia as "sovki" (pleural from "sovok" – literally "dustbin") could respect the Homeland with reverence and veneration as its worthy sons did.

For people outside aviation many things may appear strange and incomprehensible. How can we explain to them the motto of our wing commander: "If your fate is to crash, you should select yourself and be a hero in the battle to your last breath". This adage means that the flyer should reserve the last decision for himself. Actually, every profession has its own morality.

With best wishes the regiment sent me off to postgraduate education and training at the Institute of Aerospace Medicine, hoping that science will help me defend their honour and dignity. This was mostly need for accident investigations.

During the 30 years covered in this book, I made many [flyer] friends, and more than 50 have gone to eternal rest. With many of them I was close and with many I flew during my familiarisation with aviation problems. The causes of their deaths were different; in many instances they were absolutely innocent.

For more than 25 years I have dedicated my activity to study the human factors in flight. I have investigated the psychological aircrew behaviour patterns in emergency and complex flight. I participated in the design of the cockpit interior, the instrument panel, new systems of flight navigation parameters displayed on CRTs, automated control systems, and all types of emergency warning intra-cockpit devices. I have followed the evolution of all flying machines ergonomics up to 3-4 generations. My single aim was to create favourable conditions for reliable and efficient in-flight performance. The danger lurked in all stages of aircraft and flyer life. In-flight simulation and on-ground trainers initiating the real [true] environment, we obtained valuable information elucidating the causes of unreliable crew performance. I have especially felt their lack of legal protection of psycho-physiological limitation standards in unusual living conditions, even of the right to opt for action, which were dictated by the situation in the air. All aircrew behaviour in cases of an emergency, proceeds from the assumption [presumption] of aircrew guilt [human error]. The flyers knew this and many of them have suffered their cruel injustice because of assumptions of their role in flying accidents. The search was always for culprits not for the actual causes. The attitude was – the main cause of all accidents is a human factor. The investigation, as a rule, was accompanied by a "tug of war" between aircraft manufacturers and users of [aviation] technology. In this book the flying safety problem will be viewed psychologically as a moral one, and that of a dangerous profession. Based on the results of theoretical and practical experimentation performed jointly with psychologists and physiologists, as well as with test pilots, I feel compelled to show the usefulness of psychology for all aviation specialists. In each chapter there will be a systematic presentation of information about the main leading human factor reliability components. In my book one may find the proof that the flyer is frequently only a vector of a flying accident, and only rarely its source. Attention will be drawn to the source of many problems not related to the aircrew. The discussion will cover accidents and guilt of the flyer. The book will also demonstrate the role of the pilot in the defence of his right to life; the role of his internal, metaphysical, cultural and education.

Possibly, the content of my book may provoke some criticism which I will welcome. This will indicate that the reader is concerned about the fates of our flying brothers, as expressed by N. Oreshina, in Aviation Country.

The independence of judgement will support the interest of the reader. In this book there is a lot of "darkness", but, as in the picture "Black Square", by the Russian painter Malevich, based on his (her) background and spirituality, one will inevitably see the light through the blackness. Here our light is a visible way to the "Good". The flyers scrupulously observe the maxim by M. Gromov: "It is necessary to be an objective judge of one and never to accuse others or circumstances".

We all need to strive in aviation to avoid circumstances called "dangerous factors". To some extent, this is the essence of this book.

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CHAPTER 1

FLYING SAFETY: AN ISSUE OF MAN'S DIGNITY IN THE SKY

1. The Moral Principles of Independent Investigators

This chapter is an introduction to all that will be discussed in the book. Today's administrative and technical methods of aviation accident investigations are based on high-level professionalism and on diversified technical capabilities. It is sufficient to say that the number of unknown aviation accident causes in the last 20 years has not exceeded 3 to 7 percent of their total numbers. However, 'cover-ups' may change this figure when one tries to establish the truth in fatal accidents. This relates especially to the socio-psychological aspects of the investigations when 'guilt' and 'guilty' are the 'master key' to unlock the true cause of the accident. Hence, the bias of the investigators often does not represent the interest of the victims, but that of the administrative superstructure. It side steps the legal and socio-psychological estimation of aircrew behaviour, and replaces it by formal logic analysis of known rules: permitted/forbidden, man or machine, chance/relationship, violated/not violated, etc.

Experience shows that methodology is wilfully substituted for facts and rational to protect those in power. In other words, technology is, first of all, an ideology of the investigators. At the same time, socio-psychologically, the investigation should be not so much a technical, but a systematic analysis of the behaviour and tasks of the aircrew, as well as the ground personnel. Hence, it seems appropriate that mishap investigations be based on a succession of formal, socially and psychologically oriented, logic principles. What are these principles?

a. Principle of Unpredictability and Non-Uniformity of Man's Behaviour.

This principle assumes that it is psychologically true to acknowledge the supremacy of objective premises, which lead to a hierarchy of aviation mishap causes. The dominant casual circumstance is the proper social approach of the investigation process aiming at establishing the accident. Thus, the investigation assumes a social tone, i.e., when, in a list of questions the first one is "TO WHOM" has the tragedy happened, and then "WHERE, WHEN, IN WHAT?" This concerns the dignity of the victims who, when alive, were concerned about the memory they might leave with their loved ones, friends, and colleagues. The question "TO WHOM?" implies a search for valid answers to a series of questions:

- Level of psychological complexity of the emergency compared to the level of aircrew professional training and preparedness.
- Qualitative evaluation of the psychic state in such situations and its influence on the aircrew performance.
- Sociologic evaluation of behavioural motivation stemming from the degree of response to the cause of emergency.
- Time of illusory perception and distorted psychic reflection of reality [tr.note, mental model].
- Spatial and time orientation of a flight situation suggesting the accuracy of aircrew performance revealing their psycho-physiological capabilities.

In my opinion, the legal essence of such an approach establishes the right of making errors, under conditions of pre-eminent circumstances above human abilities, in an actual emergency.

b. The Principle of Personal Intellect Precedence over Standards of Performance.

Here, the socio-psychological investigation is aimed at the study of the individual and his curriculum vitae. This portion of the investigation concerns the psychological performance qualification in an emergency. The current absence of legislative edicts, giving aircrew the right to choose their actions if they do not agree with standard procedures, is virtually synonymous to aircrew guilt.

This, the following questions need to be answered to establish the facts.

What is the psychological and the psycho-physiological order of signal perception determining the psychic process of decision making?

What are the objective principles of signal perception distortion in an actual emergency, as compared to the official interpretation of manuals and regulations?

What is the difference between distortion values recorded during flight and the objective perception of the aircrew during an emergency?

What motivates non-standard actions or a professional level of performance?

These questions are based on scientific investigations of flyer's behaviour in emergencies, and need to be used by accident investigative bodies. The behaviour in an emergency is not always a series of automated manoeuvres following strictly the order stipulated by instructions. And this is in the failing of the psycho-physiological laws. Emergency aircrew performance is controlled by the intellect, (not only by skills), which implements information processing. And, if this processing is based on a screening mechanism accompanied by locomotor attempts, the decision is delayed. Moreover, if it is based on a choice mechanism accompanied by locomotor attempts, the decision comparing the flight image to the emergency image, the decision is accelerated, although it is a non-standard one.

The speed of the flyer's reaction is not determined by the amount of processed information, but by the choice of the signal's importance, which is always subjective and affected by individual personality traits.

In an emergency, flying safety depends not so much on the detailed information of the emergency, as on the whole picture including space and time, and the actual determination of the ethical limit of man's struggle with the arisen situation.

Flying performance and professionalism are important qualities in an emergency. They are manifested, not so much by the awareness of the situation, as by the response which is sometimes contrary to logic and common sense.

Under normal conditions, professionalism should not make one complacent in an emergency, i.e., in an emergency, thinking, feeling, willpower are qualitatively different then in a standard flight.

Lastly, the technological order of signal perception, as stated in the instruction manuals frequently changes, in time and space, during an actual emergency. Therefore, response absence to a signal or a distortion, as recorded on tape, is not a legal proof of guilt. Man may miss one signal when he is analysing another. I mention this with only one goal in mind: to show the real need of using a wide range of understanding man in the aviation mishap scenario.

c. The Principal of Potential Unreliability of "Man-Machine-Interface".

The socio-psychological investigation, besides establishing the main cause of the mishap, always helps to determine the mechanism of the circumstantial actions, which lead to the catastrophe by overloading the psycho-physiological capabilities of the aircrew. The determination if the overload allows to understand the many threats to man in all phases of aircraft operation: training, aircrew readiness, control, and mission management. Man's reliability in flight is directly related to the technical characteristics of the aircraft and its ergonomics.

Currently, up to 35 percent of aircrew errors are caused by the lack of ergonomic information display, guidance controls, out-of-cockpit visibility, design of instrument panel, as well as of adequate training. At the end of a sortie, better then 60 percent of the aircrews experience performance deterioration due to the exposure to extreme stress factors such as: noise, vibration, acceleration (Gs), electromagnetic radiation, toxic substances, etc. More detailed data about performance deterioration will be presented in related chapters.

Man's reliability in an emergency may be, to the degree, determined by such factors as the level of special training, high-performance, psycho-physiological qualities, competent aircraft control.

What else represents potential unreliability?

Many instructions, regarding aircrew performance in special situations, are psychologically insufficient, since the earlier mentioned time sequence of the warning signals does not fully coincide with the laws of perceptive psychology.

At least two to three failures of control instruments are poorly simulated on trainers. In 95 percent of the cases simulation concerns only counter measures, but not skills to recognise the failures.

The most important factors in decision making are practically disregarded. The most dangerous

signals are very weak and have no feedback channels to warn the crew – absence of automated control systems in all fighter aircraft, failure of control instruments on weather aircraft also lack warning signals.

One of the most common aviation accident causes is spatial disorientation. However, simulators do not include this parameter. Moreover, aircrew and ground control personnel do not undergo in-flight emergency training. The limitations of an aircraft total more than 100, but over 40 percent of these are not discussed in training classes; neither are the aircrew's familiarisation with aircraft technical operation danger ranges. The ratio of the professional reliability training under special regime to the total flying hours is 1:99. As of 1992, the total annual flying hours needed to maintain occupational skills are no more than 30 to 40 percent of those required, and this at a time when 'right stuff' pilots are scarcely 10 percent of the entire military flying population!

Pilot's reliability is determined by psycho-physiological reserves, which block the consequences of negative flight factors. These reserves are build-up during the long psycho-physiological training, which includes the combined effect of high temperature, sustained Gs, vibration, vestibular stimulation, useful signal selection against white noise background, exact movement coordination under increased Gs, depth perception in changing illumination, etc. However, such training is not yet practised, but used only selectively in aviation medicine consultation to ground or wash out pilots. Yet, in experimental medicine, the cross-adaptational phenomenon, i.e., when one system is 'assisted' by another, has been known for a long time.

This, far from being a complete list, supports the conclusion about the legitimacy of a socio-psychological adjudication that, among the unknown factors, is the potential, objectively programmed unreliability of the pilot, due to severe environmental conditions. Therefore, he is blamed for psycho-physiological incompetence and social underestimation of his dangerous profession by the senior officials responsible for flying safety.

d. The Principal of a Dangerous Profession.

In my opinion, the principal of a risky profession is fundamentally socio-psychological, because it does not deny the intrinsically characteristic possibility of aviation mishaps (probabilistic computation). Moreover, the principal is based on the understanding of man's elitism, when working for a prolonged time under the effect of mental and physical stress, and ready to face danger in the form of a direct life-threatening emergency. The 'spiritual' elitism of the flyers is created by pedagogics, i.e., and his upbringing for psychological readiness to danger. This hazardous occupation demands a high involvement in all his functions. Without an optimal functional state, exhaustion may occur, leading to inadequate performance. Thus, the proposed psycho-physiological principal helps to recognise aircrews right to free selection of performance, i.e., the right of non-standard decisions in non-standard situations.

I am convinced that we will see the day of 'enlightenment'. In the '70s to '80s the aviation mishaps recorded annually, aircrew performance was not always adequate, however at the same time, of the yearly 2000 to 3000 non-standard incidents, none developed into aviation accidents owed only to the PILOTS. Such is the reserve of the morale and performance power of man! There still remains the task of helping him socially, i.e., to recognise in every aviation mishap the tragedy, but not the blame, as well as his high standards, consciousness, and decency.

2. Who Will Defend the Fatal Casualties?

From the '50s to the '80s, aviation mishaps were rarely reported by the mass media. Usually, only low casualty accidents were reported – foreigners, politicians, or children. Lately, the first to know are newspaper and TV cameramen. It is a pity, but mass media have sown the seeds of the have truth, unhealthy sensations, and suspect every one of criminal actions.

In January 1994, a commercial TU-154 crashed in the suburbs of Irkutsk, due to an engine fire, and control system failure. Ten days following the mishap, the press released at least 20 facts, which did not explain the main causes, but only confused the issues. Some articles call the pilot a hero, others described him undisciplined and untrained.

I have participated in numerous aviation accident investigations, including government committees – IL-62, commercial accident at Sheremityevo; TU-154, commercial crash at Krasnoyarsk; air collision of Airlift Command AN-12 with a

commercial IL-14 (high life loss of servicemen and civilian passengers; (collision of SU-24 bomber with Polish hang gliders; crash strategic bomber TU-22M in Shaikovka; the death of Marshall Kharchenko on a military helicopter MI-8; and more than 40 other military aircraft crashes).

I have participated in the investigations of aviation mishaps that happened during test flights or air shows. Some of my experience may be summed up as grief, despondence, and dejection when I saw human remains being placed in a matchbox. The feeling of bitterness felt during these investigations will stay with me for the rest of my life.

I suffered because the top investigators professionalism, and their scientific objective expertise were frequently reduced to a minimum, due to interagency struggles and intrigues of the MIC (Military Industrial Complex) in the former USSR, or following the 'consulting' with the central committee of the Communist Party of the Soviet Union, in Moscow. Even such authoritative organisations as the Central Aviation Safety Inspectorate (military aviation) or the government Aviation Inspectorate (civilian aviation), sometimes silently 'adorned' the government conclusion with an 'ideological' value: "All are guilty, and no one is responsible". Why such a paradox? Maybe, the high-ranking authorities were unaware of the fact that concealment of the truth would lead to the next mishap. Of course, they knew it as well we, the investigators. And, in the case of an order from the leaders, powerful party bureaucrats frequently sent letters to aircraft designers, and to manufacturing plants, to improve technology. I have only, one hope: to restore honesty in the immense human drama of aviation accidents; namely, instil moral focus in the aircrews to resolve social protection of aircrew members victimised by aircraft mishaps. Allow me to cite one example.

I shall begin with the description of the air crash of the commercial TU-154-B-2N-85338, at the Krassnoyarsk airport, in January 1985. This crash killed 110 persons. The investigation was led by a government commission headed by L.V. Smirnov. I will not discuss the entire documentation of the two-month investigation, but only the portion that concerns the psychology of the investigator's behaviour. I do not find it necessary to cite here the names of all the participants, and the chronology of the events. Our group of psycho-physiologists and ergonomics specialists made up the subcommittee of aviation experts.

Sequence of Events.

Two minutes after takeoff, at an altitude of 2,040 meters, the first-stage compressor disk broke setting engine 3 on fire. The flames spread to engine 2 and to the tail portion of the fuselage. Eleven seconds before landing, the aircraft lost all manoeuvrability, as the control stick had become useless. The aircraft have lost all three control axes. At the crash site, the experts learned that all the hydraulic valves were shut off. In the last airborne seconds, the aircrew could not control the aircraft. "The Irkutsk aviation disaster", once more, evidenced that the aircraft lost controllability at 12 kilometres from end of the runway). It became clear that the main cause of the mishap was a technical failure, but, as it often occurs, the performance of the command pilot in his crew revealed many procedural errors. This led the accident investigators to place the blame on all the services.

The reason for a fierce struggle among various agencies (Civil Aviation Department, aircraft manufacturing industry, Civil Aviation Scientific Research Institute, services of flight operations) were many. It began because the technical record of engine 2 indicated an early warning signal, of increased vibration in engine 2. The crew was assembled before the flight; the on-board engineer was a rookie with little flying experience, and had not flown with this crew before. It is he who switched off the engine 2 instead of blazing engine 3, tried to restart engine 2, and forgot to cut off the fire extinguishing valve, etc. According to official documents, the pre-flight briefing of the aircrew was OK.

An aviation accident investigation encompasses 'hypothesis', 'danger factor', 'emergency situation', 'immediate and mass causes of mishap', 'concomitant circumstances' to insure the selection of the investigation methodology and logic. But, de facto, each biased agency gives a special value to the logic, which supports its version only.

The flight recorder was found, and the cause of the 'engine fire' was proved. Eventually, the technical specialists at the Russian Air Force Scientific Research Institute for the employment, the operation, and the restoration of aviation technology came to the following unanimous conclusion: "Metal fatigue destroyed in two minutes the first stage disk in the compressor of engine 3. The use of fire extinguishing equipment is useless in such cases. The engine fire and other malfunctions of engine 2 were caused by the fire

and the failure of engine 3. The defect of the disk is visible to the naked eye. In ultrasonic test, in flagrant violation of existing requirements, was not carried out".

This conclusion of the government committee was refuting by 6 to 4 votes, in the decision was to continue with the participation of other examiners, without interrupting of the investigation. The chairman of the investigation subcommittee of the Aviation Testing Institute of the Aviation Construction Industry Department presented his own conclusions:

"A complex situation has arisen as a result of a fire, which was not put out by the aircrew, (as was pointed out to me), due to the inability to shut off the fuel valves. Thus, the catastrophic event was caused by the erroneous action of the aircrew. The emergency performance of the aircrew was unclear and in violation of the Flight Operation Manual requirements. The level of the flight briefing was found to be very satisfactory. The aircrew did not switch on the SOS signal at the time of the emergency, radio communication was chaotic, throttle was not set on idle, the aircraft was climbing instead of descending; all this extended the time available for the emergency landing. The on-board engineer shut off engine 3 instead engine 2. This resulted in fuel spilling on the overheated engine. As the engine failed the aircrew did not start cross fuelling. The captain was unable to obtain effective aircrew interaction, according to item 24 of the flying code. Had the aircrew members been able to act skilfully and competently, the emergency could have ended safely".

And lastly, Here is the data of the flight recorder decoded at the Civil Aviation Department of the Scientific Research Institute of Flight Operation:

"Takeoff, 14.08' 43″; after 2 min. 05 secs at an altitude of 2,040 metres and at 480 kilometres/hr failure of first stage compressor in engine 3, accompanied by an acoustic boom, of the 'explosive type', lasting 0.8 seconds. The rpm of engine 3 ≅ 0. Vibration in engine 2, throttle placed in idle position. Idle is shut off in 0.5 seconds; engine 2 reaches 100 percent rpm as a result of disconnection between throttle and engine throttling. For 2 minutes, engine 2 operates at an increased thrust, and, consequently, shuts off. In the last 11 seconds, a complete failure of all control channels and loops. A flight recorder indicates a complete breakdown of the engine 3 hydraulic system. For 2 minutes the aircraft flies on one engine, the second engine operates at lower windmilling rpm. One minute before the crash a recording: 'breakdown of hydraulic system of engine 3'. In the last seconds, the captain ordered to 'take over the controls'. Vertical speed 17 m/sec, ailerons and vertical stabiliser were up. A warning signal sounds of aircraft's dangerous proximity to the ground, and dangerous banking angle. Aircrew suggest to increase ailerons by about 50 kg, and control column by around 100 kg, however the hydraulic system does not function".

Since his aircrew needed 11 to 12 seconds to touchdown, the investigators decided to test aircrew performance by modelling the emergency situation on a flight trainer.

During the simulation, using highly qualified test pilots as subjects, the score of the killed captained, V.S. Falkov, (steering his aircraft in the last seconds of his life on only one engine), could not be reproduced. Unfortunately, the government committee ignored the results of the simulated experiment.

A group of experts was formed. It consisted of A.N. Razumov, M.D and engineering psychologist; N.A. Fyodorov, M.D. and pilot; A.S. Belan, M.D. and speech recognition specialist; V.D. Popov, test pilot; V.A. Goryachev, engineer. I was appointed to head the investigation group. Colonel-General A.P. Yolkin, experienced military pilot, was the chairman of the Aviation Committee.

For the first time, large-scale experiments were carried out by modelling all potential circumstances on simulators, in strict compliance with in-flight events, and recording of all psycho-physiological characteristics, performance indices, and all voice and locomotor reactions. The subjects were 8 aircrew members of the Central Department of International Aviation Transport Airlines, The Byclorussion Territorial Department of the civil aviation (Riga), the Vnukovo civil aviation detachments, the Aviation Testing Institute of the Aircraft Construction Ministry, and the USSR Air Force. The on-board engineers of these aircrews had various levels of qualification (from first to third class), with a total of 230 to 4000 flying hours on the TU-154.

We carried out 45 simulated flights for a total of 158 tests. Since we used a new methodological approach, we describe it to improve the level of

objectivity in the investigation of aviation mishap causes. I also wish to stress that the goals of the simulation tests were defined by a government board as follows:

1) Determine the temporal sequence of on-board manual performance during development and localisation of the emergency situation;
2) Authenticate the expert conclusion of the psycho-physiological capabilities of the aircrew members to eliminate the on-board threat on the TU-154.

The tests were performed on the TU-154 simulator KTS at a civilian base for aviation flight personnel training, detachment 18 at the Central Department of International Airlines of the Civilian Aviation Ministry.

To learn aircrew performance in response to the 'engine fire', the instructor/pilots and the psychologist proposed three experimental scenarios of the accident.

Model 1. Fire of engine 1: crew performance was defined by the flight operation manual (FOM).

Model 2. Events and time of their occurrence corresponding to those registered on flight recorder (MSRP) on the TU-154-B-2-N85338.

Model 3. Was based on the actual sequence of events of TU-154-B-2-N85338 during the fatal flight.

In the last test, the tasks of the crash engineer were performed by the test engineer. The captain of each team was aware of this. During simulation, the engineer contacted the captain via voice communication, in full agreement with the actions of the engineer in the actual emergency.

As the main criteria for the aircrew performance reliability evaluation, we used the captains and the flight engineers emotional state, based on their respiratory and cardiac rates, in the temporal reactions of the engineer (emergency recognition time; separate reaction time; type of errors; information reading change based on movie recording of visual pick-up sequence; subjective evaluation by the aircrew of their performance using radio interviews).

The investigation established that the selected models differed substantially in their complexity. The neuro-emotional tension of the captain and the engineer during a standard 'engine fire drill', was significantly less than in the actual crash event. In the latter, the heart rate of the engineer had risen to 125 and the captain's to 123. Cardiac arrhythmia was also noted, as well as irregular breathing. The most significant emotional reaction in the captain occurred when the engineer shut off engine 2 instead of engine 3; the pulse rate increased to 160 and respiration to 27.

Our experiential study, of the crew emotional reactions, showed that data obtained in actual flight emergencies was 30 to 40 percent higher than those obtained in the simulator.

Therefore, on the basis of aircrew's emotional reactions, it might be assumed that the superimposed events and the damaging performance by the engineer raised sharply the stress of the entire crew.

The engineers temporal performance was as follows: detection time of engine fire (warning signal) averaged 1.5 to 2 seconds; throttle pullback to idle, when the emergency signal was presented, took, on the average, 30 seconds; yet other subjects only 7 seconds. In our experiments, the time for fuel valve closure averaged 22 seconds. The second attempt to turn on fire extinguishers took on the average, 20 seconds. The total time to extinguish the fire averaged 45 seconds, i.e., a range from 20 to 129 seconds.

The diversity of the temporal data is of special interest. It motivates one to study the emergency event, 'engine fire', as a problem demanding not only automated reaction, but also adequate judgement and solution. It is the individual strategy of decision making, along with the emotional stress that leads to a significant scattering of the temporal response times for positive actions. In adding that these facts, it should be pointed out that each test revealed that the concrete temporal response represents the manifestation of man's behavioural psycho-physiological conformity in emergency situations.

Based on the evaluation of the engineer's attention distribution during instrument crosscheck monitoring the engine gauges, it was established that attention was constantly divided between zones of visual scanning, and the introduction of a

'standard' engine fire situation, evidenced an intensification of the visual control with redistribution of the importance of the scanned zones. The times of eye fixation on the instrument 120/min. During simulation, the zone most frequently searched was that of the engine gauges, and eye shifting rose to 132/min.

The experimental data have shown that in the case of a dominant signal in the engineer's consciousness full visual control of 10 zones is psychologically impossible. A large number of visually perceived 'information units', (more than 60), by the engineer creates conditions which aggravate the concentration sharing and leads to omission of necessary reactions.

Independent of more detailed analysis we need to formulate to 'ground laying' facts which are of decisive importance to further the work of the accident investigation committee.

First: None of the test subject was able to match the flying available time, and to fly a better trajectory than Capt. V. Falkov.

Second: The performance of the engineer was filled with errors.

The most arduous work still lies ahead: to reproduce, not only the aircrew performance during the emergency, but to also simulate that socio-emotional background against which the event evolved. At that time, the government commission's tug-of-war sides, successfully pulling 'the guilt rope' from aircrew to technology, was oscillating at zero! But technology was represented by solid, socially 'heavier' figures (ministers, managers of special design bureau, scientific research institute's directors, and aircraft manufacturing plant engineers). The main obstacle was that the aircrew was a 'hostage' of the circumstances that were much stronger than the aircrew. But this needs yet to be proven. I believe that the 1994 Irkutsk crash was, to a considerable extent, the same as the 1985 one in Krasnoyarsk. The performance of the aircrew needs to be studied in greater detail. On the basis of linguistics, psychological and audio analysis of aircrew speech recordings, along with the psychological analysis of the psychomotor functions (taped flight parameters with recorder MSRP-64), and additional data on the simulator, the following was determined. When aircrew realised engine 3 was on fire, their functional work level change to a state of powerful neuro-emotional excitement. This was caused by a sudden side jerk, a loud boom, and lateral G forces. It was essentially vague, but it did evoke man's strong orientation reflex resulting in fear.

Thus, started the aircrew's awareness of engine 3 fire, against the background of a sharp emotional arousal, which became evident in their speech, articulation time, word repetition, and slips of the tongue. In 4 seconds the aircrew spoke 10 words, four of which were oral commands.

The captain, having heard the boom, felt lateral G forces, and the engines warning: "vibration of the engine 2", ordered: "shut off". Since the captain, from his seat, did not see on the instrument panel the number of the engine on fire, his command was based on the Flight Manual. The jerk and the increase vibration of engine 2 made the engineer also aware of the emergency. Taking into consideration that in the engineer's memory lingered traces of the information recorded in the log book, by the previous engineer, that engine 2 had undergone significant vibration during an earlier flight, we may conclude that he expected this to happen again. In a standard situation, to meet all the requirements of the flight operator's manual for this type of failure, one needs 40 to 70 seconds. In the actual emergency, the engineer disposed only 1 to 2 seconds to correct the first problem. However, his intent was interrupted by the captain's order: "shut off". Thus, engine 2 was switched off by the engineer, as per data on the recorder to MSRP-64, in 5.2 seconds. Just as the aircrew shouted "fire", which I consider the second problem. The engineer shutting off engine 2 may be considered as a reflex response to the boom, the vibration, and captain's order to shut it off.

Therefore, for 6 seconds after the boom, the captain and the engineer did nothing wrong. In the subsequent 20 seconds, the performance of the captain and the crew followed basic guidelines. The captain followed the instructions in the operational manual, when he ordered the co-pilot to "hand over the fire extinguishing task to the flight engineer". This was followed by his question to the engineer: "is the engine still on fire", and then, by his command to change engine thrust. The engineer's response: the captain did not hear "I shut off engine 2 accidentally", because he was talking to the tower (radio communication).

Simultaneously, the engineer's response was aggravated by the presence of two problems – shut

off engine 2, and fire of engine 3. He realised his mistake by glancing at the control panel.

Time interval measurements, and the data obtained with the eye movement recording of the flight engineers, during simulated flights, were in the range of 0.8 to 3.0 seconds. This allowed to assume that in an actual situation, the engineer could detect the fire of engine 3, from its initial stage, only at the 7th second. And, virtually, 2 seconds later he reported to the captain: "I accidentally shut off engine 2". At this moment, the engineer was faced by two highly important tasks demanding parallel actions; i.e., extinguish engine 3, and restart engine 2. He correctly prioritised the sequence of his actions by first extinguishing engine 3, and restart engine 2. He also placed the throttle in the stop position, since, according to the experimental data on the simulator, this required no more than 5 seconds. The engineer used this time and reported it to the captain. However, in the subsequent time frame, fire extinguishing is interfered by the restarting of engine 2.

Thus, in the first 20 seconds, the flight engineer faced highly challenging tasks requiring simultaneous actions. Behavioural investigation and simulator tests have shown that behavioural reactions are accompanied by emotional stress, omission of some tasks, or confusing priorities specified in technical instructions.

Usually, under such conditions, man reduces the algorithm of his behaviour on the principal of subjectively estimating the importance of the received information. We may surmise that in this emergency, the engineer had activated the fire extinguisher before reporting to the captain. Moreover, this hypothesis is not far from the truth, because he disposed of the necessary time.

Beginning from the 50th second after the boom, behaviour motivation of the captain and the engineer was driven by the same purpose – start engine 2. All this presented an additional stress for the captain. Since the ground control heard a message about the fire, in reply to his command "throttle down both engines", the captain heard the engineer: "I accidentally shut off engine 2". This differs from the actual course of events during the emergency on the TU-154. But the engineer was fully aware of the situation. His message may be explained as the manifestation of a well-known, psycho linguistic phenomenon – as fusion of two words or phrases. In other words, against the background of time restriction and association deficit, the engineer said engine 2 instead of engine 3.

Time deficit was due to the fact that the time necessary to put out one engine fire, and to start simultaneously the other engine, was greater than the time available to the engineer. The total time needed to put out the fire was in the range of 20 to 150 seconds. Time to localise the fire in the simulator was found to be in the range of 20 to 130 seconds. This time relates to the complex sequential tasks and response to information perception of more than 60 instrument panel signal lights that are in different locations. To start the engine, according to experimental data, one needs about 14 to 19 seconds. Therefore, time necessary for sequential engine fire snuffing and engine restart, is in the range of 34 to 149 seconds.

Moreover, on-board aircraft, there was a third problem substantially affecting the interaction between the captain and the engineer, and causing poor concentration for problem solving. The engineer restarted engine 2, 15 seconds after he had shut it off. And after 28 seconds, he reported to the captain that engine 2 was off. However, according to data on the fly recorder (MSRP-64), the engine was running at 37 percent rpm.

Thus, in actual flight, the engineer was faced with a new problem – failure of needed engine rpm. This allowed to infer that the gauges of engine 2 had given false information. (According to the conclusion of the experts of the Russian Air Force Institute of Maintenance and Operational Technology, the malfunction of engine 2 was the result of the fire and destruction of engine 3.) Based on the simulator test data, the engineer never took his eyes from the instrument panel. But, at the same time, from 4 min. 10 secs to 5 min. 17 secs, the captain in the engineer were both busy attempting to start engine 2, which was also probably damaged.

The statistical analysis of oral speech communication between the captain and the engineer, during the fourth minute of flight, suggested that the keywords were single words as well as whole phrases related to engine start. Of all the words spoken by the captain and the engineer during 64 seconds, 40 percent related to 'start' and 75 percent to 'engine'. Of the key phrases used by the engineer, about 80 percent related to 'start'. Based on the above data, it is clear that in this time interval, both the captain and the engineer tried

desperately to restart engine 2. This 'obsessive' state of psychological motivation may be interpreted as arising from subconscious anxiety. In this case, anxiety and, probably fear, are related to the awareness of flying on only one engine which, based on the Flight Operations Manual, will upset the earlier established routine performance. As indirect evidence of the above, is the data obtained in the simulators, where six captains, after the engineer reported that engine 2 cannot be throttled down, (a definite technical failure), did not order it shut off. In the same tests, in reply to the engineer's report of accidental shut down of engine 2, (engine 3 is on fire), the captain order to start engine 2. During questioning, all captains reported that in this situation they were not sure they could accomplish the approach manoeuvre on one engine. Only two aircrews finished the test in the time matching that of the crash crew.

Later, onboard the aircraft, new problems developed related to the control loss of engine 2 and its fire. After engine 2 was restarted, the engineer reported to the captain that engine 3 was still burning in spite of all possible efforts. This was reported at the 112th second of the emergency. And 19 seconds later there is a fourth problem: engine 2 could not be throttled down. Then the fifth problem arises – a fire of engine 2 gondola. A study of the psychomotor function of the aircrew, from the 112th second of the emergency, and during the final moments prior to crash, showed that the crew was aware of the situation and reacted timely to commands. Despite the severe neuro-emotional state, there were no panic reactions. In the last moments of their life, captain Falkov and his crew, although unable to steer to the aircraft, behaved bravely and heroically, as evidenced by the radio communication tape.

A paper I wrote about this accident, and a film recording aircrew behaviour during simulated flights, were not approved by the government commission chairman to be presented at a briefing. I was asked to surrender all to the Repository Secretariat along with the following conclusion:

"Onboard the TU-154-N-85338, an emergency occurred due to destruction and fire engine 3, the switching off of engine 2 by the engineer, and ensuing fire which forced the engineer to alter the routine course of action. Insufficient time for emergency landing, improper information about the working status of engine 2, the destruction of engine 3, all contributed to the lack of aircrew coordination. The analysis of the radio communication indicated poor psychological preparedness for such a situation, due to the lack of special psychological procedure training. Insufficient information of crew interaction, during the location of the fire, was due to lack of the captain and co-pilot's information about location of the engine fire and the 'cutting off valve', as well as in starting and stopping the engine under normal conditions. In summary: "The emergency on the aircraft exceeded the psycho-physiological capabilities of the aircrew to be able to objectively reach optimal decisions. This led to individual faulty performances".

This conclusion created a dissension among commission members, and required additional evidence. We carried out ergonomic studies of the aircrew workplace, analysed preparedness for such emergencies, and the opinions expressed by the crew. The obtained data is still available today (1995).

The psycho-physiological readiness, for special flight situations, is based on learned skills with automated aircraft. However, ground training using successive simulation and practical use of guidance controls were not carried out. Training aimed at the problem in vague, namely, poor psychic qualities development, as needed in emergency situations, particularly under conflicting, and even wrong, information conditions. Absent is the scientific subdivision of the work relating to the study of structure, methods, and means of psychological preparedness to perform in extreme urgency situations.

Common errors have not been satisfactorily studied on simulators. Yet, our investigation has demonstrated that, using trainers, typical errors, as violation of task sequence during fire-extinguishing procedures, delay or omission of switching off fuel valve, delay in switching on fire-extinguishing equipment, shutting off a normally operating engine – all did take place.

It was also determined that in cases of superimposition of several problems, automated skills are of limited help, since, in such cases, the standard behaviour changes greatly. It should be noted that the aircrews are trained by 'outside' instructors who have a diminished supervisory position. This is not foster the level of the professional efficiency.

In needs to be emphasised that the poor ergonomic design of the TU-154 cockpit plays an important role in lowering aircrew proficiency. I dare say that this cockpit has important deficiencies, which lower the reliability of crew performance. They include the distance separating the captain's workplace from that of the flight engineer (engine function information is not available on captain's instrument panel); switches of APU (Auxiliary Power Unit) are placed on the same row with those for fire extinguishing equipment. This leads to the most common error – shutting off the wrong engine; location of cut-off fuel valve is too far from fire extinguishing equipment; absence of a centralised warning system (oral cues, flickering panel, colour coding emergency switches, etc.).

I will not list the more than 100 proposals to improve the pilot's workplace. I will cite only the authenticated wishes of the pilots. Please, read attentively this modest report, it is a gist of the deep-rooted causes which have emerged as dangerous factors. Unfortunately, they have been completely ignored. Moreover, we, (the experts) were accused of attempting to discredit the best in the world – the Soviet technology. Moreover, because of these ergonomic deficiencies, common errors in aircraft steering became routine. Those flying the TU-154, (the most mass produced commercial aircraft in Russia), should read carefully what follows, and draw their own conclusions during their training in the cockpit. This is an invaluable exercise for our best aircrews.

Thus, 20-year experience of flying the TU-154 jetliner has given the crews the chance to learn the problems that may occur in an emergency situation, such as an engine fire. Here are their comments:

Eliminate the light signal of the APU (Auxiliary Power Unit) from the row of the flight signals for fire on engine gondola 1,2,3.

The government Military Standard GOST V 24396-80 (for two seat-aircraft) and the Department Standard OST 100396-80 (control systems) state: the controls to shut off the fuel valves should be placed on the fire extinguishing control panel; the controls to shut off the fuel valves should have red and white alternating stripes. However, the term 'shut off' does not correspond accurately to the designation of the aforementioned valves, because they do not directly counteract the fire. They would be better to call them 'fire valves' and group them with the emergency equipment signals.

It is necessary to incorporate the fire sound alarm and flashing light on the panel. It is also highly desirable to show not only 'fire', but also the number of the engine on the pilot's instrument panel.

The requirements and the technical specifications are in the Departmental Standard OST 1.00416-81 (system of internal signalisation of aircraft and helicopters). General requirements and Department Standard OST 1-0073-74 (complex fire protection for aircraft and helicopters) prescribe the following:

"Presentation of fire information emergency. The signal should be a flashing light and combined with either a sound alarm, an oral warning, or a vibro-tactile stimulation. The light signal panel should show the number of the location of the engine fire. If the cockpit is equipped with a universal signal panel, a pilot must be informed as follows: Fire engine..., shut off valve, speed ..., switch on fire extinguisher". This visual warning should be reinforced by an oral message. The standard fire regulation for aircraft and helicopters, established 11 years ago, reads: "the warning Fire should appear on a blinking light (1-3 Hz), indicate the engine on fire, and be accompanied by a sound warning".

The best solution to counteract fire, is to install a single switch which would automatically trigger the following sequence of events: shut down the engine by closing the valve, shut off the fire valve, close the air nozzle inlet cone, shut off the electric power supply. These decisions are legal, they are specified in the Departmental Standard OST1-00396-90: "In designing the control system, it is necessary to envision a centralised control with an automatic switch-off of several systems with a single control switch". The technical requirements of the Departmental Standard OST1-0073-74 "Fire extinguishing system must provide...the possibility of an automatic switch for the fire extinguishing equipment". Thus, the opinions of aviation staff, carrying out daily scientific investigations of aircrew emergency behaviour, are reflected in normative technical documents.

In designing new generation aircraft, and subsequently in updating them, one needs to

adhere strictly to the requirements of the Departmental Standards, enhance the equipment for a better interaction of captain and engineer, envision oral corroboration by the engineer after extinguishing the fire.

The aircrew errors registered in the accident under discussion, should be addressed not only during aircrew training (individual factor), but also as a human reaction to informational input (human factor).

In each actual mishap, one needs to determine all the factors, including the technical, which cause unreliable responses by the aircrew. I have quoted only some data obtained by highly renowned specialists of the Aviation Department. However, their recommendations were applied, at best, only in one-third of the cases. This was possible because of the law-abiding and, mainly, responsible authorities of the Special Aircraft Design and Construction Bureau named after A.N. Tupolev. The leaders of the Aviation Institute of the Aviation Manufacturing Industry concurred with the well known Pharisaic ideology of the former Central Committee of the Soviet Union Communist Party, by using the 'theatrical' expression: "Man is more precious than technology".

I realise that such sharp criticism does not make me a better person, since I did belong to the "leading cohorts of the Soviet establishment", but I do leave an alibi – my written works, and living witnesses, can confirm this.

Only one year later, after additional investigations of the aforementioned disaster, our efforts were knowledge to be most valid scientifically. But the TU-154 was not improved. Regretfully, "our ideologies" were then preoccupied with plans of world order reconstruction... It would have been better had the conscience been awakened in us all.

In this connection, I wish to add that the establishment, by the aviation personnel in the New Russia; of the Flying Personnel Association (A. Kvochur, President), the Society of the Aviation Accident Investigators, and other such groups, will prove, God willing, the true liberty, democratisation and, most of all, the birth of civil forces to defend the dignity of man in the sky.

3. Aviation Professionalism – A Guarantee for Flying and for Human Reliability

The analysis of the scientific research data of the teaching and training of aircrews, of mishap causes, of flight code violations, of the study of causes of flying motivation loss, and even of lesser deficiencies, indicated that the psychological prime mover of the negative phenomenon is poor professionalism. This does not only concern flight errors admitted by pilots during missions, but much more: poor spiritual personality, strict pedagogic standards of flying instruction, and insufficient moral and social behavioural principles in risk level planning for subordinate flyers. As you can see, I use the term 'professionalism' in a much broader sense. Thus, I need more detailed explanation to substantiate this.

The new political and economic set-up in the Russian Federation has turned the problems of professionalism into a multidimensional socio-psychological phenomenon. The economic security of the worker, including the sky 'labourer', has been removed from the government and placed on the shoulders of the worker. Consequently, professionalism serves as a measure of competitiveness and social adaptation to life in a new society. Besides, professionalism in aviation is a guarantee of flying safety and, as all other aspects of aviation, it has its own specific traits.

Professionalism is a fundamental quality of the aviator's personality. In an aviation community, the commander, who lacks the required professionalism cannot be a respected leader. Aviation professionalism is not only the platform of flying longevity, but also of a long natural life. In connection with the above, it is well to mention the great furore caused by the demonstration of our aviation technology in Farnborough, in Le Bourget, in Italy, in Malaysia, and in the United Arab Emirates. This was, first of all, due to the high mastery and professionalism of the Russian test pilots ("Bell" – Kvochur, "Cobra" – Pugachov), but, for the sake of fairness, it should be noted that these aerobatic manoeuvres were developed by several eminent Russian test pilots – V. Ilyuchin, V.I. Petrov, I.P. Volk, V. Menitsky, and others.

Unfortunately, many highly skilled military pilots and test pilots remain behind the 'iron curtain' of secrecy. These were the pilots who pioneered the new generation aircraft. They flew to test the aircraft frame strength, changes in the centre of gravity, and excessive G loads. They practised aborted takeoffs and asymmetrical thrust control, carrier takeoff and landing with shortened breaking distance, etc.

Since this book will be read not only by flyers, I will discuss now one of the aspects of professionalism the moral aspect. Every profession consists of workers, specialist, and professionals. Professionalism is the highest quality, which cannot be imparted only by the characteristics of the profession. Why? If, under professional mastery we recognise the specialist who has achieved the pinnacle of experience, then his quality will be determined, primarily, by efficiency and performance in accordance with the required norms and, only secondarily by the activity of the performer himself. The specialist/professional is a person to as obtained a high level of knowledge and competency. And this allows him to carry out the assigned mission at the demanded level of quality, reliability, and efficiency to attain uniformity of performance. At the base of such specialised training our knowledge and skill required by the occupational character of his activity. To achieve superior results, one needs to train by following an established program. Therefore, if the notion of professionalism is reduced to the term 'specialist', the main quality becomes "standardisation" or 'normativeness'. Then, the pedagogic support of the training will serve efficiency, but the methodology of the training the standard tutoring. Many professions have demonstrated that this approach allows to train sufficiently well qualified experts.

But, for a professionalism that guarantee success, survival, and safety, this approach is detrimental. The fact is that the psychological additive to professionally significant qualities for a dangerous profession specialist, such as awareness, professional knowledge, and skills, are not the central link of the personality, but only a means to develop general human capabilities and essential traits. In dangerous work, professionalism is a category of human existence representing the personal, philosophical, professional, moral, and ethical qualities of man. The core of the moral stimulus in the moral sacrifice, for self-preservation is not at the top of his list.

As I mentioned above, a risky profession demands, first of all, a constant socio-psychological preparedness to work in extreme conditions; secondly, a pronounced, innate psycho-physiological inclination assuring the possibility to react, with flexibility, not only to sociologic stress, but also, vicissitudes of life; and thirdly, an exclusively resilient nervous system allowing to form, permanently resilient neuro-psychic connections, new functional properties guaranteeing such processes as image creation, intuition, and anticipation.

A dangerous profession presents a constantly 'active' factor, i.e., a process of realisation of the deepest reserves of spirit and body which, on earth, may be called for very rarely. In other words we're concerned here with some redundancy in degrees of freedom in space and time.

What am I talking about? Under normal performance, the reliability and efficiency of man is based on general qualities of life: irritability, changeability, adaptability, energy changes, etc. when faced by an unexpected danger, man 'releases' his biophysical analogue. And, if he is afraid, it is not his 'Ego', but his instinct.

The principal feature of a dangerous profession is the fact that man can not hide from a life-threatening situation with a biological 'chandra' (Uzbek woman's face veil). Man must manage not only to evade danger, but also to surmount it; if it is inevitable, not to adjust to it, but to transform the situation to his advantage, to control it, i.e., to change his activity to another space. Men working in dangerous professions (flyers, submarine personnel, miners, divers, cosmonauts, parachute jumpers, firemen, and others) provide, first of all, safety to other people, which forms the virtuous foundation of a dangerous profession. This profound professionalism consists in taking on themselves the responsibility of personal decisions of the highest degree of organisation, of masculinity, courage, self-criticism, moral purity of motivation. I am not invoking the well-known Russian philosophy of self-sacrifice, ideological suppression, or one-dimensional human robot, it goes much deeper. In a dangerous profession, incompetence, egoism and indifference always bring calamity to others. The motivational stimulus of professionalism, in extreme situations, is not just sympathy, but mainly duty. Here lies the hidden meeting of the spiritual life, his 'cross' is to create good, transform the conscience into decisiveness, and manliness – professional behaviour.

Moreover, this may appear to be odd. Professionalism, for the flyer, as described above, begins before embracing their profession. It may begin with the formulation of man's voluntary and free choice of his destiny – to excel himself, to take risks for others. To cultivate a conscience, freedom, self discipline, good nature, and will-power are the important stepping stones of a pilots personality to attain honourable values: protect other people's lives. Thus, professional personality 'ripens' within itself, and acquires a sensitive substance of socially significant, occupational motivation. Hence, it follows that the main components of professionalism are found in the human genes. I believe that for the professional flyer, 'the spiritual space' is not a metaphor, but a social reality of an interaction with his conscience. This is the specific, systemic property which separates the professional from the specialist.

Amazingly, in the cockpit of an aircraft are two crewmembers – the pilot and the radio communication officer, two specialists, however, each with a different 'service' inner world. For the radio operator, the inner professional world consists in faithfully transmitting to the pilot the information of aircraft centres. For the pilot, the psychological inner world consists of his love of flying, and his need for spiritual freedom. Their spiritual freedom counteracts spiritual insensitivity?

Good habits play one of the most important roles in the training of flying personnel – it is a cornerstone of flying safety, and paves a 'mini free flight path' in the sky. But, this is not yet true professionalism. This term is exclusively multidimensional. It is a measure of conscious maturity, integrity, and goodness. It starts with the formulation of the pilot's personality, which consists of one main goal in life: to fly. The profession is his destiny. Thus, professionalism is a spiritual striving for the broadening of his capabilities. What does this mean for a dangerous occupation? It is the achievement of mastery at the expense of greater risks, i.e., increased probability of facing situations requiring exceeding the frame of one's psychological capabilities. This means that danger is the spiritual ecology, which forms man's character through heightened risks, and traits of his maturity and reliability. Risk is not irresponsibility but it will arise, before reason, to overcome a dangerous non-standard situation. The incentive of self-improvement by risking his life is very noble, since the highly professional man sees his final aim as a safety insurance for other people.

Aviation professionalism has its own contradictions. We do that when man flies an aircraft, he experiences a wide range of emotional sensations: from actual fear to an elated state of freedom. These experiences are strong enough to often push aside reasonable limitations, thus creating a psychological state of emotional elation. Hedonism suppresses a process fraught with grave sequelae (hedonism is elation, supreme pleasure). Here, true professionalism helps. The fact is that each new flight gives rise to new unfamiliar situations, for which the pilot has little experience. But, the intellect arises as an integral psychic means of general orientation, prognostication, and creativity. Interest for the unknown feeds professionalism, even in the early stages of the training. The cognitive interest for unusual situations suppresses the sense of fear, develops the ability to foresee the course of events, and establishes a vital attitude, not only for performance, but also for creative thinking and solution of problems. This represents the core of the psychological protection from exposure to the continuous flying stress; and here lie buried the roots of the professional and human reliability of the flyer.

The Ace flyer is almost error free, as determined by targets and conditions of flight missions. Moreover, he is 'independent' in the sky (overcomes complex flight conditions). The independence is assured by self-discipline, transition from consciousness to self-consciousness, from basic habits to formation of psychic qualities, which translate knowledge into action, and behaviour into deeds.

A mandatory component of professionalism is a structural reorganisation of the personality at work. For a professional, it is particularly difficult to imagine a specialist without imposing limitations on himself, know his body, his soul, and his strengths and weaknesses, to sense accurately the decrement of readiness to face a risk, to define the levels of his psychic state. However, whatever his flying abilities, he cannot become a highly professional expert without the corresponding spiritual culture.

Man's ritual culture is a very complicated, and hard to define phenomenon. It includes the comprehension of such high matters as good and evil, sin and repentance, earthbound thinking and universal consciousness, cosmogonic spirit and a link to the highest reasoning. The professional flyer is constantly exposed to risk, has a keener

sense of his destiny in the material world, and he sees more clearly the positive results of his labour. Thus, he feels more responsible, not only before the law, but, in his soul, also before his passengers who trust him with their lives. An error is a sin, a 'hurt' to his conscience, since the price may be loss of someone's life.

One of the ethical elements of aviation professionalism is the right of a well thought out risk. A risk in this occupation is not only the performance, but also the conditions allowing to improve professional mastery. However, risk is an instrument to overcome the natural human weakness before a danger. In this case, risk is the conscious psychological, protective action suppressing subconscious fear, and unpleasant sensations; it is the maturity test of the professional. It also means to be temporarily a 'Superman', an 'extraterrestrial', and this is the cosmogonic secret of the flying profession.

This state of the spirit, a lifting force of professionalism, is attained, mainly, by self-improvement, self-discipline, and self-development. On earth it is difficult to estimate the state of man in flight, and to render him aid. There follows, the importance of the role of inner culture of the professional when his above board behavioural norms are based on the awareness of his capabilities. This gives him the inner right to a personal initiative and planning the degree of complexity and the dynamics of acquired flying manoeuvres.

Actually, this quality, i.e., the spiritual autonomy, is an additional professionalism – psycho-physiological readiness to vital activity in an unusual environment. This means that precise knowledge of aviation laws and rules of flying an aircraft, of the automated skills, of the physical strength of the body are still sufficient to assure professionalism. One needs healthy organs for a proper adaptation of the body to G changes, new estimation of time and space, for instant recovery from a faulty perception of spatial attitude, and to work under exposure of a hardy discernible noise from a useful signal. In other words, we need not only to teach man the required professional ingenuity, but also to constantly re-train him. Thus, to achieve a high-level professionalism, is necessary to be in 'professional' health, i.e., to maintain to sustained performance under exposure to frequent extreme factors, as those pilots face only in a specific flight environment. It should be noted that 12 to 18 percent of the aircrews experience severe obsessive illusions of 'invested flight' when flying in the clouds; more than 40 percent become familiar with a phenomenon of perceiving stars as aircraft navigational lights, and, at least 25 percent, the illusion of time-flow stopping, 'stiffening' of space, 'puffiness' of the horizon, etc.

For example, ability to sustain increased G forces during aerobatic manoeuvres, blood shifting to the lower extremities, and systolic blood pressure rising to 250 mm Hg are hemodynamic changes brought about by a normal physiological reaction of the cardiovascular system, but not essential hypertension.

When flying in a highly manoeuvrable aircraft, man sees the earth 'above' and sky 'below', and at the same time, being of sound mind, he feels that his pelvis is in the usual place. His overloaded consciousness must translate this quasi world into a real world. It is hard to imagine how a 90-ton aircraft may be landed on a runway, a speed of 350 km/hr, without awakening the passengers.

I wish to say one more thing for a better understanding of the flyer's professionalism – sustained flying survival. A particular feature of the flying profession is that continuous learning of new aviation technology, (improved instrument panels, control systems, etc.). New technology places additional demands on man – absorb new ideas introduced by the aircraft designers. This is professionalism at its best – creative potential, psychic dynamic characteristics, spiritual fortitude, and natural guiding instinct. Professionalism is, quite obviously, manifested in the aircrew interactions. It is eloquently evidenced by the language of the professionals or, more precisely, by their jargon. Jargon is not only a 'compressed' experience, a sublimate of knowledge and gregariousness, but it is also the tool of spiritual understanding. Actually, professional jargon is a sign of rank, but it also reflects the symbol of the spiritual state, the expression of the loftiest feelings, incomprehensible to the uninitiated person. Slang always implies a second 'Ego'. Jargon is not so much an expressed thought, as expression of a conscious state and its relation to its double subconsciousness. Characteristically for the person in a dangerous profession, jargon often assumes the form of humour or merry jest; sometimes an unusual, significant silence. The silence of a professional, especially in emergency, is not just a psychic self-immersion, but mainly a change from speech to silence. In aviation, the

professional attains the ability to understand the physical illusions (as earth loss, extraterrestrial loneliness, and sensation of cosmogonic space). These 'sensations' of man's consciousness "THERE" and "HERE" lend, to the still insufficiently understood aviation professionalism, a specific individual meaning, and the profession is thus considered a gift from God. Consequently, the core of professionalism is the intellect. But the basic 'promoter' of aviation professionalism is man's spirituality, a living link of time and space – where we come from, where we are now, and where we are going in the future.

To support the above, I wish to quote two well-known examples. In one the life of the flyer hung on a 'hair'. In the other circumstances showed "Who is Who". These examples may help understand the nuances which separate the professional from the specialist. The first example concerns the pilotless flight of the MiG-23 fighter aircraft from Poland to Belgium, after the pilot ejected. The emergency occurred during takeoff, when the pilot heard a boom and the engine rpm decreased. The pilot assessed the situation as follows: "I sensed the heaving of the nose, as when a horse stops while jumping. The air speed gauge was at 400 km/hr; the rpm were dropping. I do not remember the altitude. I reported to the ground engines shutdown and my decision to eject".

Time from start emergency to ejection was 12″. The entire mental process was correct. Moreover, professionalism was absent, for the dynamics were considered to be final. Yet, at an air speed of 400 km/hr, the aircraft could have continued to fly. The time, in which the events developed, was not sufficient for engine failure, yet it was estimated as final. The second-rate flyer had assumed an emergency much before contrary information could refute it. The thought of doom was dominant in his consciousness. The decision was adequate, since he could not steer the aircraft for lack of power.

Second example: MiG-29 at the air show at Le Bourget. It was to be a demonstration of a new fighter aircraft. The conditions were very difficult – very low speed and altitude. Test pilot A. Kvochur had been chosen to fly the aircraft. At an altitude of 500 meters, not far from spectator stands, the pilot heard a 'pop' coming from the engine. This is how professionally he assessed the situation: "my first thought was – engine boom? I look for the engine's rpms, they were dropping and, simultaneously I felt the aircraft turning to the side of the spectators, and losing altitude. Instantly, I tried to check the turn; the second thought was not to leave the aircraft. I attempted to put both engines to full afterburner and wait... But the aircraft was still pulling to the right, the engine did not have enough time to increase the rpm, and the angular spin velocity was gaining. My mind was not on the altitude loss, but on correcting the banking angle in order to change the flight path from spectators. My soul was in pain – first day of the air show and I had to eject. When I did eject, I thought it was too late. I remember the falling aircraft, the white sky and no parachute canopy... It is the end... I curled up... Heard an explosion... Felt I was lying on the ground... I was still alive. The hands and the legs were moving". Time from emergency to ejection 7. Two similar events, two decisions, but how great the difference!

In the first mishap, performance of the flyer was based on the principal 'stimulus – reaction', i.e., from event to response without an intermediate comprehension of the situation, in the second mishap the pilot was continuously the master of the situation. And where was his instinct for self-preservation? It is suppressed by the professional behaviour to seek the safe place to crash the aircraft, as far as possible from the stands, and to survive. All is compressed into 7 seconds. But to become truly professional, one needs, first of all, to devote as much time as possible to flying with little rest. All was compressed in these seconds – thoughts, spirit, honour, and love of life. By all means, not all aviators share such an attitude of professionalism, especially the conformists. These men, and I, know that even currently, the teaching of aviation professionalism is based on standardised learning of stereotype skills.

It is well known, that the performance of the flyer is not simple, and that the technology is multifaceted, that flying conditions are changeable, and the tactics not streamlined. Each flight mission entails a different risk with the probability of emergencies, with autonomy of decision making of moral problems, and, sometime, determination of life preservation – one's own, and that of others. The experiments I carried out, including flying with aircrews, have evidenced that stereotype, standard performance is reliable only under conditions of a familiar environment. In the case of a sudden, contradicting information, stereotype behaviour becomes unreliable in more than 60 percent of the cases. This unreliability is manifested by wrong decisions, by delayed or omitted performance, by confusion, and even by

panic reactions. Inadequate performance followed in all cases with an element of surprise, and the first class flyers were especially surprised by their lack of combat readiness.

The analysis of numerous complex aviation tests brought us to the conclusion that the theory of pedagogic professionalism is based on the principal of dynamics and development, which elicit constructive decisions and moral deeds. In the practice of aviation teaching, we have constantly met with inflexibility, inertia, and redundancy. This is a result of not only the actions of some individual administrators, but, and unfortunately, also the lack of verification of their psychological and pedagogic credentials. And this, despite our well-known aviation refrain: "Our documents are written with the blood of our crash aircrews".

Take, for example, the manual "Course of Combat Preparedness", which is based on collective experience and reasoning. This manual lists the rules to attain mastery – the goal of the student. Social reasoning suggests that the task of this document should be one of changing the character, and the document itself, should not be inflexible, but a road to professionalism. Life is dynamic – changes in technology and tactics, in ideology, in personal biases, and even in social consciousness. For this reason, the principal of dynamism assuring professionalism, even in such documents as "Course of Combat Preparedness", should exert a definite, creative influence. Thus, it seems reasonable that the above-mentioned manual should have, figuratively speaking, 'blank sheets' that may be candidly filled by supervisors.

In considering the attained level of the flyers readiness, to raise the ceiling of complexity one needs to develop the professionally important qualities in accordance with the operational unit's location (geographic and weather conditions), the specific mission of border defence, interaction with ground armed forces, etc. It is important that you understand me correctly – professionalism belongs (and it must be so), in normative documents, together with strict rules, and some freedom to attain the highest results.

Let us, now, consider not the essence of professionalism, but its morality. The pilot's profession is dangerous but also romantic. The demands exceed nature's endowments; thus the pilot must continually improve their psyche, body, spirit, and will power. The teaching of aviation professionalism starts with the formation of the trainee's personality. However, in the aviation academics, pedagogic psychology for personality development is minimally used by the instructors. Yet, from the viewpoint of professional psychology, the learning of applied subjects should keep in step with the formation of central motivations and vital attitudes of the flying occupation. Much remains to be done at the primary stage of aviation cadet training, in order to provide the pedagogic professionalism, which consists of the spiritual foundation of moral values as a life alternative, since unprofessionalism of the flyer is, in the last analysis, immoral. But, since the psychology of the instructor prevails over the psychology of the educators, the air academies fail to develop the required intellectual and creative performance. Often, this task is substituted by using strong moral examples taken directly from aircraft accident investigation data.

It is likely that some traditional aviators may object to such an approach for teaching respect of aviation rules. However, I wish to stress that this is the key to personality formation of dangerous occupation professionals. And this may be accomplished only by psychological and pedagogic means, and met by volitional and stereotype subject matter paraphrasing of knowledge.

During a mission, there might arise a situation, of which the aircrew may not be immediately aware, and may not have yet the necessary experience to cope with it. This is when intellect and foresight kick in with a creative solution. Thus, motive and interest of the unknown are born. It is the trainee's awareness for cognitive interest that promotes confidence of a happy ending of the mission, suppresses fear, enables to control the course of events – professional approach not only for the accomplishment, but also for the creative decisions to solve problems during the flight. This is one of the approaches of psychological defence against a stress of aviation work. Thus begins the professional and human reliability of the flyer does start.

Emergency is not the predetermined destiny of the flyer. "An incident" – says Air Marshall I.I. Pstygo – "may be legitimate, but never, fatal". If we understand and acknowledge the laws of aviation psychology, we should also, in principal accept that many aviation rules are violations, first of all, pedagogic misreckonings. The result of various investigations, of healthy and ill crewmembers, has already evidenced that the cause of many of the

professional 'ills' could be traced to their training at the Academy. I am aware that it is unusual to hear that striving for enjoyment, cognitive activity, and improvising may subconsciously, develop a sense of resistance to aviation professional rules. But, these are facts which should be taken into account by educators. At the initial phase of professional training, when one only begins to understand aviation rules unswerving fulfilment necessity, the greater the pedagogic gift of mastery of the instructor's comprehension, the more and a deeper he 'penetrates' the self-consciousness of the cadet. To practice self-control, continuous self-improvement is to reach for flying excellence – attain professionalism. The flyer, whatever the level of his performance, can not be a true professional without the corresponding spiritual culture. Here, the term 'culture' means the need to develop the intellectual potential, not only the performance.

This concerns also the mature flyer. What frustrates the modern, professional pilot? I will only take upon some psychological aspects. Based on questionnaires, the flyers are disturbed, first of all, by the hypocrisy of the professional environment – use technology to its fullest, but at the same time, do not exceed its many operational limitations; prepare yourself for promotion to first-class rating, but do not exceed the limits of greenhouse safety, over-conscious simplification, or duty flying hours. Independently of the accident causing factors, and the much broader variation of aggravating concomitant circumstances, the pilot is practically always found to be guilty. The modern military flyer endures very hard living discomforts and surmounts them heroically. But he experiences much greater stresses of innermost psychic discomfort, of mistrust, refusal of for promotion, 'red tape' innovations, indifference to his romantic, adventurous spirit to conquer the unexplored space. When he is punished for being 'romantic', ridiculed, when his altruism causes distrust, and a spinal column fracture coincides with undercarriage damage, for which he is highly fined, professionalism turns to bitterness, animosity, anti-social behaviour, an even treason (allow me to remind you about the defection of the Soviet fighter pilot to Turkey on MiG-29). Psychology has an explanation for this negative behaviour. As a rule, the Air Force chooses bright young men, emotionally sound, and ambitious. A good upbringing usually facilitates the development of their personality. The least deviation in their social microclimate, especially in the professional relation's environment, has been found to be extremely painful, although concealed. This is followed by unfounded behaviour. The fragility of the flyer's inner world is not so much stipulated by the complexity of his work or dangerous sorties (this is mostly perceived as enjoyment), but the psychological limitations imposed by the bureaucratic non-flying, ground controllers upon his moral incentives and initiatives. Therefore, the pedagogic training, regulating the balance of the personality drives and social needs, should be placed on a much higher level. The best remedy to prevent aberrant behaviour by the aircrews is a continuous reinforcement of aviation professionalism. The above-mentioned negative extremes, or not, as yet a real malady, but only early signs of it. We need to realise that the wings of flying professionalism are held up not only by the air, but also by the confidence in colleagues and compatriots, the respect of the military brotherhood, including veterans; also by the confidence in the mind and conscience of technology designers, the support of scientists, instructors, and of psychologists. This is the essence of our democratic life. Without it, it is impossible to attain true professionalism, because its absence presents a constant danger to the life of the pilots and their passengers.

The professional flyers are the "salt of the earth" in any country. There life and their work have demonstrated that danger intensifies the development of man's humanity, moral drives, and to 'do good' – they are trained to be aware of themselves and others and, consequently, to develop the highest values of morality.

CHAPTER 2

MAN'S PSYCHOLOGY OF A DANGEROUS PROFESSION

1. Concept of a Dangerous Profession

It is an historic fact, that the leading traits of aviators are courage, heroism, and romanticism. Such a social scenario, at some point, encourages youth to test itself to the breaking point. Eventually, the aviator's career became a popular profession, and aviation one of the main civilian and military transportation systems. The romance with flying eventually dwindles. However, with the technological progress of increased aviation reliability, man became more and more dependent on the various jobs related to piloting planes. In some aspects, technology has transcended far beyond the psycho-physiological capabilities of man to control the aircraft. And this has increased the probabilities of danger and risks during flight missions. The psychological danger is not the actual emergency situation, but the inability to readily eliminate it, due to the natural psycho-physiological limitations of man's psyche and physiology. The acknowledgement of increased danger met with a powerful resistance of our government ideology. Yet, such recognition served as a scientific foundation to establish flight safety services and research to study aviation ergonomics. The concept of a dangerous profession covers a wide range: it encompasses a lot of various occupations, (besides flying), related to extreme conditions. Hence, it is logical to start with the theoretical aspect of this dangerous profession as a whole.

A dangerous occupation demand, firstly, a socio-psychological readiness to work under extreme conditions, pre-determining a leading role of personality characteristics (motivation, goals, character, will power); secondly, a sufficiently pronounced innate intuition assuring a high-level support to the homeostatic functions of the neuro-humoral system; and, thirdly, an exceptionally adaptable nervous system allowing a flexible brain function to provide creative processes, such as intuition, forecasting, and heuristics.

The performance in a dangerous occupation can not be guaranteed only by knowledge, skills, and ingenuity; this is its essential psychological feature. In a dangerous profession, man often encounters situations that require him to exceed common logic and to perform counter psychological tasks. The investigation of man's behaviour in dangerous situations has shown that man is exposed to complex biologic and physiological stimuli which, in turn, lead to the disintegration of his performance. The spatial disorientation, in particular, interferes with the psyche process of signal recognition, and decision making. The stereotype activity, based on automated skills, interferes with the analysis and estimation of non-standard situations. Dominance, is a special feature of the nervous system, i.e., the concentration on a strong stimulus becomes 'inverted', namely inertia. Here, we have a psychological 'short circuit' to the question – "What has happened?" – and a delay of the transition to the necessary performance. The principal feature of a dangerous profession is the instinct inherent to all living beings to evade danger. Taking this into consideration it is difficult to assume a successful professional training, without first learning human physiology, and the psycho-physiological cornerstones of human behaviour.

This is directly related to the understanding of a dangerous profession. But, its social context is not less important. It is common knowledge that dangerous profession workers, (flyers, submarine personnel, divers, cosmonauts, railroad engineers, crane operators, automotive drivers, operators of power stations, and other industrial concerns), first of all, ensure the safety of others, and represent the moral cornerstone of a dangerous profession. Therefore, the psychological and pedagogic task in a dangerous profession consists of a methodological research and a practical implementation of moral human behaviour under extreme conditions.

The need for psychological support is linked to natural and social phenomena that threatened human lives; they are earthquakes, floods, fires, epidemics, and ecological disasters. There are many dangerous situations related to transportation, nuclear power plants, mines, energy facilities, chemical manufacturing plants, etc. This requires elaborating a completely new approach the psychology of dangerous professions, is necessary, not only to guide man's behaviour in extreme situations, but also to effect profound moral human behaviour. Extreme situations of

broad public repercussions have a hidden, psychological effect on the consciousness of many peoples, by distorting spiritual attitudes, anxiety, panic reactions, depression and, sometime poorly controlled aggression. Thus, the task is to offer professional knowledge, to create skills, and to teach professional reliability in extreme situations. The gist of such psychological training is a combination of professional training and social education.

The task of training a reliable professional, who can overcome any one dangerous situation, presumes the formation of moral behaviour under extreme conditions – readiness to assume the responsibility of proper decision making, highest personal self-control, and courage of self-sacrifice to save others.

The proper foundation of this training rests on the fact that man at all stages of his education, must be taught moral principles – first of all, conscientiousness, for in dangerous occupations incompetence causes grief to others. The psychological teaching of moral readiness, to overcome extreme situations is not so much empathy as activity, where motivation should not be the motto, "company in distress makes trouble less", but the conscience. This psychological training facilitates the formation of civil behaviour.

In teaching professional reliability in dangerous occupations, one may use computers to create models of responsible decision-making situations, and training for extreme psychological situations, by simulating extreme industrial situations on special trainers, with behaviour analysis of actually occurred extreme situations. The goal should be training to handle unusual situations, reach complex decisions to create heuristic programs, probabilistic prognostication, i.e., tasks that enable flight survival. This should be complimented by occupational orientation and attitude advertising, by professional and psychological selection for dangerous job positions, and creation of goal oriented training courses, manuals, and movies.

The final goal of the government to attain these goals consists in teaching high moral standards, social stability, high-minded entrepreneurial qualities, and understanding government regulations in life's extreme situations.

Today, one of the dominant social phenomena is the scientific and technical progress in all the departments of the national economy. For teachers and psychologists, the technical progress represents not only a professional interest, but also a social one, namely, how can this progress influence the spiritual world of the growing generation, the lifestyle, the culture, and, lastly, the health of the students.

Before the contemporary society is the task to raise the humanistic essence of labour, i.e., to achieve maximum productivity by optimal health conservation, and emotional and spiritual contentment. At the same time, the technical progress has given birth to a new production technology (automation) changing the structure of work. From the psychological and pedagogic viewpoint, this means that the system of professional and technical education acquires a new quality – it does not prepare the users of the technical progress, but potential vectors on which will depend on the enhancement of work productivity. The scientific foundation of education, mainly professional and technical, should be a reliable step, allowing to enter real life with confidence. And the contemporary technologic production is such that, without special psychological preparation, he is not always capable to cope with the mental, the emotional, the physical, and the moral stresses.

Hence, it follows that contemporary living poses problems of secondary education. One of the fundamental tasks of pedagogics consists in preparing the new generation to be creative in the foreseeable future. In this connection, it is methodologically extremely important to unify academic pedagogics and social behavioural pedagogics.

Currently, the training of man's readiness to work is based only on past experience, without consideration to novelties introduced recently into production. Actually, a new generation entering the workforce often shrinks from reality requiring independent performance, because of the image formed during this training of the 'life model'. Unpreparedness is observed mainly in attempting to overcome problems in stressful, unusual, and extreme conditions. The severity of this problem is determined less by unpreparedness than by the absence, in the young generation, of, a drive to learn professional readiness. In this connection, let us pose the following question: Is there really a social want for this readiness? It seems that the preparation of youth to face the future is unthinkable without taking into account the current general trends of present-day reality.

First of all, we are concerned with a rapid change of the environment in which man lives and works. It suffices to mention, that in one generation, the speed of transportation has increased 2 to 5 times, the speed of technological progress of automated production lines 8 to 14 times, the need to make important defence decisions 30 to 40 times. Today, a human error may lead to the loss of hundreds, or even thousands lives, and to the destruction of property in millions of dollars. Thus arises the need for the establishment of special social qualities in man to make decisions in unusual situations.

Fast changes in industry, military, and political situations, as a reflection of modern life, require objectivity and urgency from pedagogues in the methods of training and new principles of developing human abilities, to ensure knowledge and skills for decision making. These abilities are determined by the psychological and pedagogic conditions supporting the progress of integral psychic qualities – emotional, volitional, and moral qualities.

In comparison with the '50s, the useful life of the equipment, of technological processes, and of new concepts, has decreased by 1.5 to 2 times. In some departments of the national economy, the turnover of technology occurs every 7 to 8 years. Regrettably, the pedagogic teaching methods and the professional attitudes are inflexible. As a result, the production of new technology is sometimes still based on conservative thinking and old procedures.

As a result of delayed methodological professional teaching and training, to manage a new technology under better controlled conditions (time deficit, speed of production cycle under unusual conditions, fabrication and transportation report about 70 percent of breakdowns and accidents caused by unreliable human performance. In the overwhelming majority of cases, inadequate human performance occurs due to psychological unpreparedness to unusual situations. Presently, there is a vital need for enhanced professional reliability, and for new pedagogics aimed at performance training under unusual conditions since, at present, uncommon life situations are more the rule than the exception.

The issue of professional reliability will be reviewed in a separate chapter. I wish to draw your attention to the phrase: the better the professional is trained the better he/she will manage emergencies. However, this is relative. The scientific data has eloquently revealed that highly qualified individuals, lacking special preparation to handle extreme situations, can not guarantee the needed reliability. The most complicated task for man is the process of decision making. Experiments have shown that in emergencies more than 3/4 of the time is spent on decision making after detecting the problem. This is stipulated not only by insufficient information, or poor professional training, but in 50 to 60 percent of the cases, by the fear for the consequences of one's actions, for the possibility of error making, of weak drive, of dependency on guidance, and of a weak character [personality].

The specialist with professional experience acquired only under standard conditions, as a rule, is unable to perform efficiently in a non-standard situation. The psychic standard behaviour operates somewhat differently in an extreme situation. For example, during a standard activity, the dominant motivation improves performance; in an emergency, it may shrink perception and distort the estimation of the actual threat. If in the standard professional behaviour the fixed stereotype, as a basis of automated skills, facilitates performance in an emergency, it slows down attention concentration from reproductive functioning mode to productive, i.e., to become aware of new information and of new decision making.

The psychologists have determined important psychic qualities which warrant successful performance. They concern operational thinking and anticipation. With these qualities man, by recognising some separate signs of not yet unfolded events, may anticipate the course of their development.

For the pedagogue, the process of professional reliability is very important, for it allows to develop the beginning of a creative process in man. Only well developed creative abilities allow to establish an emotional 'buffer' against the main stressors – unclear information and lack of confidence in the success of the taken decisions. The course of action in non-standard situations ultimately allows to establish a professional reliability of man's instincts and to boost his cognitive activity. When these basic psychic qualities are established, the task of the pedagogue, as a professional and technical educator, will be to use a creative and professional approach.

The process of the professional and technical education should be a true model of the career of

future specialists, including knowledge of potential extreme situations. This requires establishing the aforementioned qualities, in order to help the professionals to sustain extreme conditions and to be ready to face an emergency. This should help one in choosing a profession and to understand, not only the future occupation, but also to examine one's own possibilities. This necessity is dictated by practice. For example, the experience of aviation training reveals that out of 10 to 12 candidates, who will "work in the sky", only one has the necessary psycho-physiological qualities for such duties. Life has shown that a specific personality and psychological qualities are essential in high-risk professions.

Allow me to list these qualities. In physiology, it concerns the capability to restore the functional state, in a limited time interval, and to avail oneself of physical reserves when exposed to extreme factors of an aggressive environment. Among the psychological factors, it concerns work capability under conditions of informational uncertainty, combined activity of equally motivated task accomplishment, and a high degree of sustained interface. With regard to social personality qualities, it concerns the inclination to altruism, to risk taking, to action, to kindness, to humour, to sociability, to overcome adversity – emotional perception of the profession, i.e., a 'whole personality'.

The formation of professionally significant qualities in non-standard situations should be considered as organic components of working education. Virtually, any productive activity does not exclude emergencies, therefore, the professional must be ready to render help, to accept risks and, in some cases, even to sacrifice his own life. Thus, the training of non-standard situations should be viewed as a pedagogic approach juxtaposing labour and moral education.

Performance should not overmatch the level of man's ability to solve problems; because, psychic instability to stress may lead not only to professional misconduct, but also to tragic consequences for others. Indubitably, this will require a pre-emption system of a multi-layered preparation at all levels – physics, military training, classroom training, professional and technical (models of problem situations). Introduction of computer-aided learning with principles of problem situation solving will sharply improve professional reliability. It may be asserted that pedagogues, with their didactic arsenal, are capable to change the trainers, the simulators, and the computers into tools of cognitive activity. It is possible to build training fundamentals of man's performance in non-standard situations, by mentally transforming the unexpected into the expected, the unfamiliar into the familiar and, thus, into easily surmountable obstacles. It follows that professional reliability is assured by unified efforts of pedagogues, psychologists, methodologists, instructors and master educators. The most important element is the extra task of the professional preparation to perform under dangerous conditions, not only in conformity with one's professional duties, but also with ones conscience.

2. What Makes an Aircrew Sometime Unreliable

I have always maintained that an increase in accidents, due to human unreliability, is a natural phenomenon. Scientists have predicted this a long time ago, but for some reason they were not taken seriously. The reasons are many, but I will dwell only on those the aviators are still unaware. First of all, to blame rests on the aviators themselves who, by professing of searching for the guilty since the '20s, have formulated a cliché comforting to all: man is the final link in the chain of accidents. Only in the last two to three years, it has officially acknowledged that pilot error is far from being always the cause of an accident.

The guilt transfer to man has been possible, first of all, because of limited knowledge of man's psyche, his psycho-physiological behaviour during flight, and his motivational needs. Aviation research and development deals with the technical safety of the aircraft, while the reliability of man's performance in flight is the separate responsibility of the flying academy. According to statistical data the ratio of aviation incidences due to technology failures and human error is 3:7. The dramatic relationship is not so much in the quantitative development as in its gist, since the cause of the human unreliability factor as before, is the pilot. What is the source of this paradox? Firstly, despite the essential growth of the complexity and diversity of the new technology of combat training missions, aviation pedagogics still uses the principal: "flight on the ground", "synopsis instruction". On the modern simulators in is possible to efficiently simulate no more than one third of the procedures of combat training. The transition to the new generation aircraft entering combat units, as a rule, lacks dual

control equipment and trainers. It should be added, that each new generation aircraft is accompanied by "act of state tests" with the list of about 200 to 300 ergonomic and technical deficiencies, which are in part eliminated with the removal of the aircraft from armament inventory. Unfinished work is disseminated by specific limitations. Rarely, special drills are used to adapt the flyers to limitations. As a result of poorly designed third generation aircraft more than half of the flying errors were completely unexpected by the aircrews, since their professional skills were developed on previous generation aircraft.

Moreover, there is a substantial difference in the concern of "top-ranking authorities" for the research in the development of aircraft and flying safety. Specially designed bureaus, tens of scientific and research facilities, experimental production factories, test flying complexes, and proving grounds were built. Many problems were solved with the aid of the Academy of Science. For the development and testing of the fourth-generation aviation technology, the cost averaged 1.5 to 3 billion rubbles. But to enhance the human reliability factor, i.e., improve selection, training, education, technical teaching aids, etc., the allocated money was, at best, only one hundredth of the above mentioned figure. For example, the study of all the problems related to man's adaptation to the planned MiG-29 fighter aircraft, the Russian Air Force Institute of Aviation and Space Medicine was doled out only 800,000 rubbles for the five-year plan. Consequently, despite previously available research data, we were not given even the minimum required for the flyer's eye protection against the quantum radiation beams, no stress recovery centres, centrifuge trainers, computer-aided systems which could increase by 2 to 3 times the efficiency and reliability of flight crew, as well as their professional mastery. It was no mere chance that, before the transition to the fourth-generation aircraft only 21 percent of the flyers were diagnosed to be ill, while two years later, sick call increased to 40 percent.

For many, this was not a secret. The primary cause rests on the methodology of the man-machine system for reliability is solely projected for the aircraft, while man's reliability is not the direct competence of the aircraft designer-builder. And, in spite of all this, the flyer's efficiency depends directly on the conformity of the aircraft control to improve perception of guidance control, on cockpit visibility, on instrument panel illumination, on the instrument panel layout, on conformity with the flyer's body size, and on the degree of protection against noise, vibration, electromagnetic radiation, etc. In other words, the human reliability factor should be included by the aircraft designers already in the drafting stage. In the following chapters, I will show that about 40 percent of errors are due to modern technology, therefore, the responsibility for the decreased performance, due to ergonomic deficiencies, may be attributed to the aircraft designers.

But we need to give them some credit for their accomplishments. In developing the fourth-generation aircraft, the ergonomic aircrew reliability has improved. It suffices to say that, in comparing the MiG-23 to the MiG-29, the number of human errors has decreased by 3 to 4 times. New aviation technology gives a greater degree of attention to the flyer. These new aircraft give the flyer much more autonomy of manoeuvre option, require a dual sense of responsibility and awareness of his limitations. Flying safety on the fourth-generation aircraft depends, as never before, on the degree of the flyer's self-consciousness, and his cultural behaviour.

Again, we have a psychological paradox. It would seem that as the aviation technology requirements are growing, and the aircrew problems increase, one needs to reinforce the overall training of the flying personnel. For example, during combat manoeuvres, the body weight of the pilot may increase by 9 Gs for one second, while during carrier landing, the G load on the spinal column may increase 7 to 8 times for 1 tenth of a second. In this connection, the problems of aircrew protection, and the providing for their families in case of loss of life or health, should be a moral duty. Unfortunately, nothing is done at any level of the aviation communities – no professional orientation, no selection, no training, no rest etc.

Impartial statistics of accidents, in more than 60 percent of the cases, are related to aircrew violations of established norms and rules, i.e., "lack of discipline", "excessive self-confidence", and technical 'ignorance' of the equipment. Practice has shown a psychological paradox: the flyer and the aircrews are not at the forefront of their flying safety endurance. All this leads me to focus on the chief factor of flying safety on the flying man, on the psychology of his personality, i.e., his drives, motivations, goals;

moreover, the flyer is not only far from being indifferent to his fate, but also to that of others and the fate of aviation in general.

To illustrate the above, I would like to cite some results of questionnaires, on flying safety problems, administered to middle level aviation commanders. All the participants had a high-level professional training and an exceptionally positive flying motivation. We shall try to answer the question: why pilots violate flying rules?

Pilot Ch-a. The pilot violates flying rules only because of a continuous decline in pilot's prestige, and he finds satisfaction in new flight conditions. Flying personnel cannot be treated as in any other profession, because they work in an unusual, emotionally loaded environment. Simplification, in the last years, has taken gigantic steps, encourages the flyers into flight regimes, which are standard for the flyers of the senior generation, but are forbidden and less accessible for them now. Hence, arise non-standard situations that not every flyer is capable to handle. Unhealthy envy and underestimation of own ability pushes the flyers to repeat some flight elements, for which they are not yet ready.

Pilot K-n. Unjustified self-confidence, conceit, drive to test himself in an 'acute' situation to earn flying authority; frequently, fear of punishment and reprehension by other flyers for aborted missions or non-accomplishment of a difficult task.

Pilot P-a. Most flying rules are meant to simplify missions which, to a considerable degree, limits aircraft and man capabilities, debilitates flying skills, leads to panic and impulsive solutions [in situations] which could be used quite safely for training in actual flight, predominantly as psychological and behavioural therapy. Many flyers distinctly comprehend that, and their own risk and responsibility to broaden the capabilities of the aircraft, and those harden themselves psychologically, and lessen the probability of incorrect solutions and actions in complex situations.

What does all this mean? First of all there, is evidence of lack of discipline; secondly, there is an insufficient level of professional training to handle non-standard flight conditions; thirdly, simplification, absence of individual instruction, overstating the evaluation of actual professional proficiency; and fourthly, dependence of undisciplined behaviour on the psychological micro-climate, and maturity level of immediate commanders [supervisors].

As can be clearly seen, the problem of aviation rules violation encompasses all life facets of the aviation operational unit. It is unlikely to reach success in prophylactic work, if all problems of aviation safety are reduced only to the flyer's culpability. In light of the aforementioned, let us consider this problem from a more generalised approach.

Flying safety is a multifaceted problem that concerns the maintenance of rules, regulations, recommendations, and the defining the flying performance evaluation. One of its specific features is that it 'feeds' on controls which are created by other services. This is not good, because the nearest causes overshadow the more distant ones. As a result, the operational tasks prevail over the prospective ones. This dialectic controversy could be overcome, if the flying safety were to be endowed with more functions, as protection of aircrews from final accusations in cases where charges come from tens and even hundreds of links supporting flying safety. Metaphorically speaking, flying safety is a strategic plan of all vital aspects of an aviation unit supported by scientific foresight, and prophylaxis related to those links of the system, in which one might expect a decrease in technical, professional and psychological reliability. In this connection let us review some factors which, independently of the flyer's circumstances, have increased the aviation accident rate.

At first, let us analyse the current demographic aviation statistics. For the selection of aviation candidates, a battery of tests was used which helped to estimate the psychic and personal qualities required for the successful training of aviation professionals. Using data of 25 years and a 9-point evaluation scale, subjects were divided into four groups. Those in the first group were accepted without competition; those in the second group were accepted based on competitive examination; the subjects in the third group received waivers; and those in the fourth group were not fit for flying training. An examination of the predictability of the tests revealed that rejection in the first group was only 2 percent; in the second group 10 percent, in the third and the fourth group 23 percent and 70 percent, respectively. A more detailed review showed that the cadets of the first group had a 14 percent error rate, while the cadets

of the second, third, and fourth groups had a much greater error rate: 25 percent, 50 percent, and 92 percent, respectively. On the basis of these data, stricter enrolment requirements were introduced. Normally, the process allowed 10 to 12 potential candidates per vacancy, however, in some years, there were only 1 to 3 applicants per vacancy. This meant that the issue of flying safety was under government control. The information received from a large database (more than 20,000 subjects) established that flight academies had been accepting more than 60 percent second group and only 10 to 15 percent first group applicants. Beginning with the '70s the prestige of the military aviation, in the eyes of the whole population, sharply dwindled and, consequently, the competitiveness among the future aviation cadets diminished, resulting in a trend of enlisting more and more third group applicants.

An analysis of the flying adaptation process, by the applicants of the third group, has demonstrated that they commit more errors, are more frequently ill, and have a significantly reduced flying longevity. In the '80s and '90s, not more than one-third fully qualified for flying training, 15 to 20 percent graduated with poor and 50 to 60 percent with average performance. The analysis of individual psychological personality data, (more than 800 flyers), evidenced that about 15 percent presented prognostically unfavourable personality traits: impulsiveness, social isolation, mistrustfulness, emotional instability, anxiety, excessive egocentrism, narrow-mindedness. Among the commanding staff, about 8 to 10 percent presented negative personality characteristics. Hostilities, marked egotistic attitudes, rudeness, inability to understand subordinates, excessive aggressiveness, uncontrollability, indecisiveness, and predisposition to conformity (N. Lukiyanova, V. Zvonnikow). One can thus conclude that the psychology, leading to diminished flying safety represents a drop in the professional prestige and indifference by the government.

Next, but by no means a less important factor of man's decreased reliability in flight, is the insufficient protection of the flyer from exposure to factors as high temperature, noise, vibration, electromagnetic radiation, fumes of burning oil, resins, etc. All above cited factors apply to a variety of aircraft in which, admissible norms and standards were exceeded by approximately 2 to 5 times. The clinico-psychological analysis of the health status of medically disqualified flyers has shown that, against the background of insufficient environmental protection, the damaging factors affect the organism at the cellular and systemic levels.

It should be noted that the environmental factor is not considered to be a flying safety factor, but is left to the consideration of the Health Department. Thus, after 15 to 20 years of continuous work, aviation personnel has evidenced, in more than 80 percent of the cases, a hearing loss of different degrees which, to some extent, affects flying safety. Psychological flight factors are also to be considered here.

Flying is a special domain of human activity, where man's natural gifts can not fully compensate extreme factors. The scientific studies of psychological, physiological, and physico-chemical reactions of the flyer, when compared to specialists of professions on the ground, have shown that:

- secretion of hormones, enzymes, sugar, and other biochemical substances of flyers are normally 3 to 4 times higher, and during flight, may even be 10 to 12 times greater;
- tension and attention concentration in the first hour on a fighter plane, is equal to 8 hours of stress for any ground transportation operator (driver);
- during flight, there is a constant disparity between signal perception and the actual gravitational axis of the body in space, due to changed earth gravity resulting from sustained G forces, which represents a double stress on the brain: 1) mission fulfilment, 2) constant correction of spatial attitude.

The fighter pilot, in contrast to any other work on earth, reacts physically to a false view of the world (the earth is above him, the familiar environmental cues are distorted). The extreme psychic stress is due to the constant separation of the false from the actual information. In the absence of earth cues, the flyer continually correlates the results of the psychic false information (from the encoded symbols) with the awareness of the actual movement and spatial orientation of the aircraft. Awareness 'dichotomy' is a unique feature of flying psychic activity.

In modern, highly manoeuvrable aircraft, the blood pressure of 25 year-old males may evidence a short-term increase up to 240/150 mm Hg, and a cardiac rate of up to 180 beats per minute, which

sometimes causes hemorrhagic petechiae. The recovery time of the central nervous system, after three missions on a MiG-23 averages about 8 to 10 hours, on a MiG-29 and a Su-27, 38 to 44 hours, respectively.

The acceleration impact on the spinal column, (especially in the cervical region), during landing on a runway is about 1 to 2 G over a time interval from 0.1 to 0.3 seconds, while on a carrier, with a tail-hook landing device, the peaks are at 5 to 8 Gs for 0.5 to 0.7 seconds.

These facts revealed that flying safety should have been, (long before these aircraft became operational), the concern of specialists in the fields of medicine, psychology, and ergonomics. Unfortunately, this was not done and, as a result, we can expect a greater reduction in flying longevity.

To be fair, ergonomics has brought about some cockpit improvements to the fourth generation aircraft. These include thermal control in the cockpit by upgrading the ventilation equipment, improved cockpit illumination, and decreased noise and vibration levels in some helicopters. But the flight safety specialists were unable to fully apply technology to maintain aircrew professional health. For example, it is difficult to explain why technical progress has enhanced 10 times the aircraft engine power yet; thus far, it is still not possible to measure the characteristic vibration of an aircraft in flight and total absorption of electromagnetic radiation. It is also difficult to explain why ventilation is available for the computer systems but not always available for cooling the undergarments. It is even more difficult to explain why computer technology can operate the engine and the weapons, but cannot control the environmental parameters of the cockpit. Flight recorders evaluate the technical parameters of the aircraft, but not the psycho-physiological parameters of the pilot. The organisational structures of the flying safety service react very poorly to the technical progress.

Allow me to quote some examples. Currently, there is a trend to raise the cockpit 'altitude' in some aircraft which in prolonged flights may increase the probability of decompression sickness. Aircrew performance experience will play an important role in prolonged, (more than eight hours), missions on fighter aircraft lacking sufficient food and water supplies, as well as waste removal. New headgear equipment will increase the load on the cervical spine during G manoeuvres. Increased aircraft manoeuvrability, engine power, radar radiation, on-board laser generators will boost the negative effect on the human organism – loss of spatial orientation due to effects of time variable, sequentially changing +/-Gz accelerations, especially during instrument flight conditions. It may be stated that in the last 15 years, flight trainers were delivered to the operational units, after the aircraft had become operational.

The personality study of a professional, and the conditions threatening his performance, allowed to establish some important professional pedagogic factors. First of all, one finds a gap between social funds invested in the development of the new technology, and the expense for learning the skills to operate and use this technology. This creates a series of undesirable consequences. Some of them are: 1) failure to use available technology to the fullest during the 'assimilation' process of the newly developed technology. The 'assimilation' unwarrantedly lagged, due to the lack of the necessary level of knowledge, skills, and work habits of the specialists, and lead prematurely to moral fatigue rather than equipment deterioration; 2) new technology has raised the cost of errors in the man-machine systems. A study of these causes indicates that they are linked to requirements of the maturity and values orientation level. Professional and technical education, lagging behind the revolutionary technical progress has combined modern professionalism and the high-level of technological performance to conservative thinking and the outdated training. This approach evidenced that professional reliability of specialists is useless without seriously embracing the entire system of professional and technical training. I shall now talk about the attitude toward the present state of aviation pedagogics.

The psychology of man's pedagogic training process has shown that physical, moral, ethic, and spiritual ordeals begin with the inability to understand and resolve non-standard situations both in worldly and in professional situation. Here, the 'kicking in' of knowledge, speaks for a professional ability of a rapid reaction to extreme conditions.

Training and education of an aviation cadet requires a moral upbringing and, form the didactic point of view, this training develops creativity and cognitive activity. The important educational task consists in teaching initiative, in solving multiple

tactical tasks, inoculation of moral principles, allowing the pilot to take the responsibility for decision making. This involves intellect. If there is true pedagogics, there are pedagogues and intellect. If they are absent, we will have imposed performance. Only high human qualities, in a pedagogue, shape a multi-system personality, namely, freedom of choice. If the flyer (or anyone in a dangerous profession), is not free to choose, he is unreliable. Having participated in many aviation accident investigations (cause and effect relationships), I am convinced that the bureaucratic teaching of choice suppression has led to a delayed use of the emergency escape system. Every year, flyers perish in approximately 40 percent of the mishaps, yet they had sufficient time to eject.

Since the work conditions in aviation are attended by life risks, the study of general subjects serves not only to acquire knowledge, but also to recognise 'self' or 'ego', which is achieved by the strict demands of the flying profession. The moral didactic work of teaching dangerous professions performance is developing a man in a man. Allow me to cite an example in which the pilot must face danger. It concerns a combat incident of airman A.V. Garbuzov during the 1987 campaign in Afghanistan. I'm quoting the airman: "At the beginning of the attack, I launched non-guided rockets and then I dropped bombs on an arsenal. In the process of climbing to 4300 and 4500 meters, I heard a powerful blow coming from an engine. The pilot on the supporting aircraft reported that my aircraft 'was on fire'. After this, radio communication stopped. The instrument panel indicated a fire in the left engine. I placed the throttle of the burning engine on 'stop' and switched on the fire extinguishing system. In 5 to 6 seconds the right engine fire warning light came on followed by the failure of the generator, transformers, and the hydraulic system. In 8 to 9 seconds the aircraft turned to the left and rolled 180 degrees. All control was lost and the plane entered a downward upside down rotation." The pilot ejected. I will quote the psychological state and the performance of the pilot, as he perceived them and wrote about them himself.

"I felt a strong impact in the engine area… Is it really kaput? However, I thought I could still try something… The radio equipment failed… I had to rely on myself. It's time to shut off the engine. How unpleasant the flashing of the warning lights… The second engine also on fire… It seems I am flying without the tail elevator… Cannot control the aircraft… I am forced to eject… I will hang in the parachute for a long-time before the eyes of the enemy… I need to load my Kalashnikov. What a pity, the ground is so far. The aircraft is falling, the first blast was powerful, I am sorry for the aircraft loss. I see the enemy positions… They will shoot me, of course, and I will not land on the ground. How come they do not shoot? This being the case, I'll shoot first. Strange, they don't react. I hope not to break my legs... It hurts to fall. I land. Aviation technician Urzhenko is not a good boy, 'cause he forgot to put in my portable survival kit the grenades. It's well, that I put them in my pockets. It is necessary now to climb up the mountain, there the search and rescue helicopter will detect me. It's good, I knew, how to pull out the radio sender equipment… I climbed to the top of the hill. What a panorama! In this place I'll survive the whole day, until the cartridges last… I have 7 hours of cartridges and 2 grenades… I should prepare all. I see a couple of Mi-8 and Mi-24… They come for me… If I could only go home… Commander, well done… you found me in no time. As I was flying home, I thought… my wife and son are waiting for me at home… I am really lucky!"

He was lucky! Much of his luck depended on training, on the work of pedagogues, and of flight instructors at the Air Force Academy. The flight instructor is a schoolmaster; his perfection demands the assertion, by example, of dignity and moral principles, which he expects from the cadets he educates. We are concerned here with specific qualities of teaching:

1) mastery of life risk limits; risk plays a positive role, because it contains the spiritually realised freedom, dictated by professional tasks;
2) create the drive to fly by transforming performance motivation into the central life interest.

A retired test pilot, N.T. Tenitsky, once said: "A fish out of water soon stinks. Why? When you are in the sky, everyone relies on you, you are needed. Now that need is gone. Advice to find a job does not help, for flying has been my only love all my life". Since motivation starts at the Academy, it is important that the instructors be the formative models of the cadets. In 1989, we carried out a psychological study of the flight instructor's opinions about their profession. All complained about a serious deficiency of higher education, lack of skills in the field of psychology, interpersonal relations, group (crew) psychology, counselling, low esteem, and family problems. Moreover, they

also related that, despite the negative aspects of the professional conditions, their commitment remained unshaken.

Mishap investigation is in dire need of democratisation. Presently, it is the main ethical problem of flying safety. The determination of accident causes is not only a professional, but also a moral responsibility to prevent future occurrences. Conscience separates good from evil. Psychological specificity of aviation mishaps consist in the fact that he who knows (but not always) the actual events, "has taken them with him", and cannot participate in the search for the truth. Therefore, in such cases, the allegation of guilt rests with the high moral responsibility of others.

Regrettably, the flyer is too often blamed for the mishaps. I would try to convince the reader that the flyer frequently is not so much the cause, as the involuntary participant of an incident caused by circumstances and conditions beyond his control.

My intention is to draw attention to hidden circumstances, which are not always sufficiently considered during the search for the actual causes of a mishap. They involve the individual characteristics of the flyer's personality, the motivation of his performance, his professional culture, and the psychological climate of the Wing. It seems that the aforementioned list of circumstances, and their relation to accident courses, facilitates the attitudes of the social consciousness needed as a moral component to determine the causes of an accident.

It has been established that in such a case, the psychological climate is manifested by communal grief and bereavement. The flyers can easily imagine aviation life; for example, for night missions, everyone knows the time they end, and when all activities on base come to a standstill – a student writes his undergraduate thesis, a wife helps the children with homework, a family prepares to go on vacation. Each person is busy with his or her chores, but in their 'subconscious' they hear the noise of jet engines, or some other sounds peculiar to an airbase. And suddenly – silence for 10 to 15 to 30 minutes. Such stillness is stressful, freezes the soul and forces one to go outdoors to speak soothing, meaningless words with neighbours. Different pursuits, yet the feelings are similar. They are brought together by subconscious anxiety. There is yet no news of an incident, but in their heart is an uneasy feeling. This reinforces the moral ties of the aviation community. Hence, at first, there emerges the moral side of our attitude for an aviation mishap, and only later the service connected duty. This sequence allows a psychological catalyst for a sincere and impartially responsible search for true causes and not a search for 'scapegoats' to evade guilt.

I am thinking that flying personnel does not violate flight rules, that their actions are free of negligence, carelessness, and lack of discipline, and that investigations of aviation accident maybe unscrupulous. All this may happen. However, the 'official' leading the investigation does not always understand how the flyer's consciousness perceived the complex situation, since the tape recorder does not register the emotions which influenced the evolution of the events. This, it is appropriate to pass from the procedural evaluation of the flyer's performance to the estimation of his motivations. The ethical problem of human guilt in the determination of aviation mishaps consists in establishing rules that identify the blame in a mishap.

Currently all is very simple: there is a document, a procedure, and a regulation, and the least deviation from them is considered a violation, which means, the pilot is guilty. The basis of this mechanistic approach is the psychological ignorance of the 'experts'. We all know that the events are described in the document, and these events, in a real stressful situation, are perceived in a different temporal sequence. This sequence is determined not only by instructions, but also by the importance of the signal. The decreased engine rpm are felt by the flyer as a sensation of linear or angular acceleration, which occurs 2 to 3 seconds before a signal lights up on the instrumental panel. The document, which regulates emergency aircrew behaviour, does not differ, at all, from the document which regulates aircrew behaviour in a normal situation. In other words, in an emergency, man is expected to perform in a standard automated manner.

Disregard for human psychology leads to ascribing errors to the pilot, when they are actually due to psychological illusions – lights in the fog or haze, psychologically distorted estimation of time in extreme circumstances, and light contrast of perceived signals, all are beyond the analyser's threshold. Truthfully, we condemn flyer's behavioural errors, although we do not always know the rules of human behaviour.

Allow me to cite another example. During rain, snowfall, fog, haze, bright landing lights are always perceived in an illusory manner: the brighter the closer, but for pilot Petrov 10 m, but for pilot Sidrov 1 m closer. It is a problem when Sidrov does not understand Petrov, especially if he is the commander. Ivanov, on the same aircraft, performs 20 movements more than Petrov in one minute. Ivanov's sensitivity of the nervous [receptors] perceiving angular accelerations is higher. His are not 'superfluous movements', but a purposeful response to incoming signals. This is by no means true for every erroneous performance.

In this case, attention is focused on the moral attitude of some officials, mainly "their right is to be always right". However, in evaluating flyer's performance during complex situations, the official's doubt about being right is necessary, especially if we acknowledge the psycho-physiological limitations in the flyer's performance. This is an emotionally loaded legal aspect of the issue, but it is also a strictly scientific one. For example, under exposure to high accelerations the flyer must work using several muscular groups. Anti-psychological tasks are not excluded even when aircraft control is based on one coordinate system, while the intended task is decided on another. As a result, circumstances beyond the control of the flyer bring about the loss of spatial orientation.

From these examples, it follows that we have a reliable technology and healthy, workable individuals. But in some situations, the flyer must admit his limitations, since the response requirement surpasses his psycho-physiological capabilities. The moral aspect of this is that the error, objectively registered as an action by the flyer, is simultaneously also an error of the whole system. Probably, we need to improve aircraft construction concepts by introducing error information due to deficiencies in the flyer's workplace, and in other features of the aircraft.

Accurate data about technology deficiencies are important for future improvements. To improve them, by restricting or forbidding instructions, may not be psychologically correct. It appears that the main aim of flying safety is an enhancement of its efficiency at the expense of a validated decrease of the number of restrictions. But they should not be introduced at the expense of the conditions ensuring profession reliability. We are concerned about humanising the flyer's work and about his personality. Under the term 'work humanisation' I mean to create conditions conducive for the best results of man's work, maintain his health, be able to give him moral satisfaction by understanding his needs, and his usefulness to others. Therefore, conditions are not only of physiological and health, but also of social importance, because they support health preservation. The socio-psychological factor of waning reliability among aviation specialists runs parallel to decreased job prestige as well as the near sighted attitude of society to man's dangerous professions. The requirement of including national minorities into Air Academies is a typical example. Of these (minorities) only 42.5 percent did complete the training, while the dropout rate was less than 5 percent for cadets belonging to aviation sports clubs.

Presently, the cause-effect relationship between personality type and professional reliability are well established, i.e., between the degree of characteristic personality traits and erroneous performance. Unfavourable qualities of those below the second class professional selection evidenced the highest positive correlation coefficient.

The reliability of dangerous profession specialists depends mainly on their morality, which is closely related to their social status: family, future, awards, etc., as well as on their professional motivation. Our study found the presence of negative flight motivation in 19 percent of the Army aviation aircrews, in 16 percent of the fighter aircrews, and 18 percent of the aircrews in the Air Force Strategic Command. The main causes of motivation loss were difficult conditions in units with educational institutions, living conditions, uncertainty after joining the reserve, and poor possibilities for individual professional accomplishments.

In the presence of negative motivation, the wives may be of substantial influence. More than 600 families were questioned on several airbases; only 30 percent of the flyers regret the choice of their profession, but among their wives up to 69 percent. Dissatisfaction with the geographical location was 11 percent for officers and 20 percent for wives; family problems (occupation, fatigue) 27 percent and 50 percent, respectively. The flyers work 332 hours per month, while government employees work only 176 hours.

These data suggest a potential human unreliability when both body and mind are subjected to high physical and psychological stress. This conclusion

was reached during the campaign in Afghanistan: after returning home, more than 40 percent of the flyers were medically disqualified from flying duty. All this demands to place man at the centre of all flying supporting services. All who support performance reliability for aircrews, must introduce viable work and 'benign' activity for the flyers. This means to create conditions which warrant highest work efficiency, maintain health and moral satisfaction from knowing that they are needed and useful.

In the foreseeable future, I will be facing the following tasks to solve the problem of enhancing man's role in safe performance.

Psychological and social 'asepsis' of essential activities in aviation communities during the reform of government policies.

Sanitation is concerned with validated information of the true conditions of aviator's work; legal norms of social protection in the case of flying motivation loss due to professional health deterioration or lack of daily duty standards; accident investigation based on the "presumption of innocence" principle considering all possible factors, including personal responsibility of the flyer; establish new medical avenues to preserve occupational health using rehabilitation centres, advanced computer systems allowing the flyer to control his own state of health; self evaluation of flight readiness; establish a higher psychological and pedagogic school for flight training instructors; introduction of new didactic methods to teach the flyers to replace current "mistrust of control and critique" to "trust by self-control and self-critique".

Technological break through in the pedagogic process using new technical teaching aids.

The main issue is to build simulators capable of reproducing the effects of psychophysical interference's inherent to flying activity (effects of acceleration and earth gravitation on the vestibular apparatus, illumination (brightness) changes, noise, aircraft control changes of the ordinate axes during spatial orientation, etc.). This would permit to teach different flight phases and types of combat. The research of hybrid computer technology of functional simulators, for teaching adaptation to operational thinking problem solving, would allow an automated conclusion based on performance dynamics, their deterioration, and to strictly regulate the degree of complexity of the presented material, based on the individual capabilities of the trainees.

Design of a man-machine system to enhance human performance capabilities.

The research and development specialists at the Institute of Aviation Medicine plan to include, in the early design stages, a computer consultation system to generate data estimation of potential human unreliability depending on work conditions. These data will allow optimal decisions in the selection of protective measures, as well as recommendations for occupational disorders prevention. We might also include here the automated system for the prevention of unexpected loss of consciousness in high-performance aircraft, by improving the perception of flight information during exposure to high Gs.

The realisation of the above mentioned technology is nothing more than the replacement of an outdated machine-centric principal, for a more anthropocentric principal in human engineering design, i.e., the transition to the recognition of man's overall dominant values. If, in building an ergonomic aviation system, we are successful in restructuring our thinking and activity in this direction, we then may hope for a positive solution of the dramatic 'collisions', on the job, and in the private life of the aviators.

Aircrew Performance in Emergencies.

Man's perception and handling of information is a complex psychological process entailing several psychic functions such as sensation, perception, memory, reasoning, etc. This process consists of two parts: 1) it is the function of a signal, i.e., it has a reflective character; 2) it represents the inner content of the psychic transformation of the signal into the situational image. During instrument flying, the activity of the flyer is strictly determined by the information model he is using. From here follows the mandatory sequence of events, forced tempo and, finally the probability of time deficit. However, the reliability of reception and treatment of information depends, to a large extent, on the ability to deal not only with the available signals, but also with their dynamics. The compulsion factor in the process of information gathering evokes a psychological adaptation mechanism, such as extrapolation (prognostication), which are the basis for anticipating decisions. After flight experiments, carried out by research co-workers (Ye.A. Derevyanko, N.D. Zavalova, B.A. Polyakov, B.M. Pikovsky; by pilot-physicians N.A. Fyodorov, I.L. Kamyshov, V.G. Kuznetsov; by medical doctors I.D. Malinin, V.V. Lapa;

engineers L.P. Vokhmyanin, A.M. Safronov, G.B. Anisimov, et al.), it was found that in the process of visual pick-ups of flight parameters, the flyer moves his gaze over the instrument panel concentrating mainly on gauges which, in his mind, are most important, thus realising the so-called 'coordinate orientation'. Therefore, when the flyer concentrates his attention on the panel, he is tuning in on the perception of a possible event. This is a short time interval of a visual fixation on the gauges of 0.4-0.8 seconds. Such an adjustment to an anticipated event not only enhances the sensitivity of the receptors, but also reduces the time of perception, leaving more time for visual attention. Moreover, it was established that during visual control of the pitch angle, the useful motor activity, aimed at maintaining the parameter in a lateral control channel continues. In the case of any in-flight emergency, the flyer is forced, first of all, to change his stereotype performance of reception and information processing. This change evokes the splitting attention phenomenon between control of current activity, and processing the new unforeseen decision. Man's psychic function switches the entire neural formations of receptors and analysers to a new activity regime.

The arising of an in-flight incident, as a rule evokes emotional stress, which may facilitate or deteriorate the process of reception and treatment of information. In an emergency, the attention is centred on a limited number of objects and tasks. Interference of the information reception process may lead, not only to an increased attention concentration on single signals at the expense of others, but it may also cause an incorrect psychological attitude for the anticipated information. Under experimental conditions, two-thirds of the pilots did not respond to a sudden engine failure signal, despite an adequate layout of the warning devices, since, in the anticipation process they had assumed that a real engine failure could not happen. In one of these experiments the flyer did not correctly read the engine gauges for 62 seconds, he considered them to show normal performance, though they had shown changes in the first 4 seconds after the introduction of a simulated engine failure (Ponomarenko V.A., Lapa V.V. "Profession – flyer", 1985, Moscow, Military Publisher; Ponomarenko V.A. "Psychology of life and work of the flyer", Moscow, 1992).

The next typical change in the process of information reception and processing, in an emergency, is the transfer from quantitative visual pick-up of gauges to a qualitative one. The following description, by a flyer, of his own state during an unanticipated flight incident may serve as an example: "I felt weight and pressure on my body. My eye movements increased, the gaze seemed to 'run' over the gauges and, what was remarkable, while I usually see all the scales, now I only saw the needle pointing up or down". Thus, an emergency situation distorts the process of reception and processing of the information. This may manifest itself as a transfer from a quantitative to a qualitative reading, no perception of a useful signal due to enhanced attention concentration on other objects; distorted perception of a useful signal; perception of the expected instead of the actual signal; incorrect estimation of the perceived signal due to ambiguity.

Reception reliability and processing of incoming information may be enhanced by training and by improving gauges and signal systems. By 'improving', I mean introducing into the building process of the aircraft the knowledge of the psycho-physiological structure of the flyer's performance and of his basic psychic functions. The success of an efficient instrument perception depends, partly, on how well the incoming emergency signals meet the following requirements: concentration on emergency situation; provide an understanding of reasons for incidents, provide help for timely and correct decisions, help to avoid gross errors during the transition from 'current events' to the elimination of an emergency.

Therefore, information reception about an emergency, begins the moment attention is drawn to a new stimulus. An emergency signal is usually quite unexpected. The flyer may be busy with work demanding his full visual or audio concentration. Against a background of focused psychological activity, the foci of arousal are formed in the brain cortex. The psychology of this phenomenon consists in that the new signal received by the first sensor, different from the normal flow of stimuli, is blocked and, therefore, not recognised. Form here follows the necessity to provide the needed 'attracting effect' – the first principal requirement, which should guide all aircraft designers. The attracting effect is the biologically conditioned adaptation reaction in man – the orientation reflex.

Thus, the psycho-physiological mechanism, at the basis of the information reception origin, is the orientation reaction allowing signal delivery by destroying the stimulation focus in the brain

cortex. Considering the above-mentioned circumstance, the technical solution for the warning signal was often though to be based on the following assumption: "The brighter and the louder, the better!" However, this turned out to be wrong. The error consists in ignoring the fact that psycho-physiological processes of reception and processing information are inseparable, because they are organically interrelated. Moreover, specificity consists in the fact that information processing is based on other psychological relationships, rather than those of signal reception. For optimal information processing, emphasis must not be on the physical intensity of the signal, but on its importance for the flyer, i.e., the semantic meaning of the stimulus. In other words, the reaction to the emergency signal is determined, not be the signal itself, but by the evaluation of its meaning for the flyer. The psychological basis of this law is the comparison process of incoming information with that stored in long-term and operative memory. The act of comparison is a thinking process and is defined as one of decision making.

From this short exposition of two different psycho-physiological processes – reception and treatment of information, it becomes clear that only a one-sided augmentation of a warning signal intensity does not always lead to the intended results. This means that an excessively powerful signal might slow the current activity, and therefore destroy the mechanism of time-shared activities of current flight parameters, and of decision-making in a non-standard situation. In other words, such a warning signal may become meaningful, but not as the carrier of semantically important information.

Moreover, the extra intense signal may provoke a psychic stress, reinforce the disrupting effect of an emergency situation, and slow down the switching over to a new algorithm of action. Hence, the importance of the psycho-physiological requirement is as follows: at first, should not only distract the flyer, but mobilise the flyer to the necessary performance and the necessary counter-action. This must be followed by another rule concerning the selection of criteria of flyer's performance in special flight situations. It is important to warn the flyer from committing a typical error when human efficiency and the signalling device are evaluated only on an attention demanding effect.

As I have noted previously, the reception and the processing of information are inter-related, although their mechanisms are different. Proceeding from the psycho-physiological conformity of the processes of reception and treatment, one should conclude that it is wrong to evaluate the reception of information as a separate process isolated from decision-taking.

Presently, information reception of any flight incident is realised with the help of one or group of displays, with sensations of angular and linear accelerations, muscular efforts on pedals and control stick, noise, etc.

Let us view some quantitative characteristics of the flyer's perception of all types of signalling devices under various working conditions. Let us rest our glance upon the more relevant quantitative data on time of reception and time of treatment of information. (The data are the result of unique experiments performed in flight and in simulators). The detection time of an emergency situation, perceived with the help of one or a group of displays, varies in the range from 0.3 to 5 minutes. Moreover, the detection of instrument failure, as a rule, is attended by a whole series of errors, since after the instrument failure the flyer continues to react to false information. We also investigated the possibility to improve pilot information reception, and processing in an emergency situation, by using a light indicator panel with oral cues. We used different types of command and warning signals.

The experiments were performed on a simulator and during flights. Our test pilots included: G.M. Shiyanov, I. Volk, V. Loichikov, P. Levushkin, A. Kostyuchenko, and others. We recorded the flyer's eye movements in flight, radio communication and control stick movements, which allowed a clearer separation of the reception and processing information from the immediate locomotion action.

We have analysed all cases of delayed responses of a flyer indicator panel signals. It became clear that reaction time, exceeding 12 seconds, was registered in cases when the flyer mistakenly responded to a false alarm. In such cases, the flyer, before initiating the recommended action to move the lever to 'emergency' position, had tested its authenticity. This behavioural strategy is often confirmed in real emergency flight practice: the reception of information, presented to the flyer by

the voice synthesiser, was more procrastinated than in the visual form of a written speech warning signal.

I would like to draw the reader's attention to the accomplishment by the flyer of false alarm commands. In experiments, using oral command warning systems (autopilot failures), there were 22 false alarm commands. Despite the fact, that all flyers were notified in advance of the possibility of false oral speech alarm presentation, in 12 cases the response was erroneous. In the case of engine failure, the false alarm command as "Throttle to stop position" occurred 27 times. Despite the normal indications of all instruments and displays controlling the function of aircraft engines, in 11 cases the pilots switched off the engine. In 23 cases of a false alarm of instrument failure, 18 flyers switched on the written speech warning signals on the indicator panel.

In most instances the errors involved semantic commands of oral speech warning signal presentation. Taking into account the fact that such ill-considered reactions to false alarm is rather characteristic for several categories of failures, we formulated the technical specifications and requirements for a system of oral signalisation. Jointly, with the Flight Testing Institute of Aviation Manufacturing Department, we have studied some forms of signalisation with absolute equality of conditions (same flyers, same mission goals, same constructive layout of warning signalling devices).

These data concern both, the reception of the information and its treatment. Please, note that the time of information reception starts with the displaying of the signal and ends the instant of pressing the button, (signal received), while the time of information treatment is the interval from pressing the button to the beginning of the time of decision making.

Analysing these data, we conclude that the use of a central fire-warning indicator enhances the efficiency of detection, especially of those regimes where the attention of the flyer is strictly concentrated on the performance of one task.

According to responses of questioned flyers, such a signal not only attracts the attention, but also facilitates the psychological 'tuning' on forthcoming actions and to counter-act failures. Flight exercises of several complexity levels, including the 'interception mission', 'formation flight', 'terrain following flight profile at extremely low altitudes were used for augmented workload during test flight and simulated flights on ground trainers.

These data were obtained in actual low altitude flying aircraft, searching for small targets on the ground. During these flights, emergencies were presented on the panel along with central fire warning (bright source of light on the upper edge of the head-down instrument panel).

It should be noted that in flights, where a head-up display was used, both processes improved noticeably. These scientific facts served to illustrate the aforementioned psycho-physiological prerequisite that the quality of reception and treatment of information is determined by the ability to rapidly switch attention. In fact, by using information on the head-up display, the flyer can constantly and simultaneously be informed about flight parameters and the ground environment, which allows him to perceive the emergency signal.

Thus, these experimental data confirm the importance of instrument signalling devices, which warn the flyer about emergency situations. It might appear that perception errors are virtually excluded, however, it is not always so. Very often, in an emergency situation, we have instances where the presentation of a good visual signal, is not perceived at all.

Consequently, let us analyse another feature about the reception and processing of information in emergency situations. It is well known that in an emergency the pilot needs to mobilise all his reserves, the protective and compensatory mechanisms, even subconscious reception (the static reflexes).

All these psycho-physiological qualities create a pattern of actions which promotes the detection of an emergency situation. The autopilot failure was detected during angular and linear accelerations for 0.27 to 0.3 seconds, on control stick for 0.8 to 0.9 seconds; engine failure sensation of turning (angular acceleration) for 0.8 to 1.0 seconds, while the signalisation about these events was perceived in the range of time intervals form 1 to 15 seconds (These data were received in flight test experiments with participation of leading test-pilots E. Knyazev, H. Adamovich, Yu. Kurlin, V. Vasin, and others).

A striking finding with these flight tests is that, even after seeing the deviations, the flyer often showed a prolonged time interval of 1 minute and more, to decide what course of action to follow. The nature of the human error rests in the psychological conflict between instant sensation and delayed instrumental verification.

Delayed validation usually occurs when an emergency warning signal is outside of the normal visual scanning pattern during instrument flight. Another characteristic phenomenon is perceived with the instrument alarm signal before the flyer he sees it on a corresponding display; this timely signal hinders the decision taking. This was confirmed by investigations about the psycho-physiological capabilities of flyers during in-flight engine failure of the military cargo plane AN-12. Engine failure was introduced quite unexpectedly, with two indications of the aircraft power. (Chief test-pilot was K.V. Chernobrovkin, leading test-flight engineer was A.N. Dusheba, the leading psycho-physiologists were N.D Zavalova and V.V. Davydov).

Thus, for the estimation of counter rotating reactions of flyers at engine failure, we have opted for two temporal indices: detection time and recognition time. For the detection time we have considered the time interval from the moment of engine failure to the first oral input [response], which indicated, that the pilot suspected something was wrong in the engine function parameters. For the time of recognition we have determined the time interval from the moment of engine failure to the moment of oral input of shutting off one of the 4 turboprop engines. Thus, the time of recognition included the time of decision and knowing something was wrong.

The first mode is instrument indication: drop of fuel and oil pressure, decreasing exhaust gas temperature (EGT), fall of momentum (rpm), etc.

The second mode is signals in the form of lighting lamps, two of which ('engine failure' and 'wind-vane pump is working') are located on the panel above the head of the pilot, an another the rotor blades are switched off, on the instrument panel of the aircrew captain (left-seat), and still another, "icing of inlet vectoring apparatus" (vkhodnoy napravlayushchiy apparat), is on the instrument panel of the co-pilot.

Besides the two instrument modes of information presentation, the flyers received immediate information due to their own sensations. These signs may come from a turning moment, a change in muscular effort on the pedals, a change in back ground noise, or a shift of the flyer's body from the gravitational vertical. The objective cinematographic registration of eye movements, and of the radio communication, established the priority of incoming signals of various modes of information to the flyer. The first information perceived by the pilot comes from the muscles and the ligaments, the so called kinesthetic signals (up to 1 second), then for 0.1 to 0.3 seconds via transfer of gaze to the visual information from the power equipment displays, which control the engine's functioning, and at last he perceives the light warning signals. Based on these data, we advance the hypothesis of the following information gathering algorithm model.

The first pulse, instigating the flyer to search for information, comes from linear and angular accelerations due to the stopping of one of the four engines, and the subsequent occurrence of asymmetrical thrust. Simultaneously, the flyer feels a change in the leg muscles (on the control column pedals), and in the surrounding noise. As a result, the pilot assumes "something has happened with the power equipment". This compels him to gaze at the instruments display panel (in 0.8 to 1.0 secs) and, first of all, at the rpm. We found that the most generalised and concrete index, the emergency situation itself, remains out of the attention sphere of the flyer. This might be explained only in part by the distribution of the four signal warning lamps in the cockpit layout.

They flyer needs confirmation of the received signals. During engine failure of one of the four turboprop engines in autopilot regime, the rotation of the blades and the drag sensations are insufficiently strong to suspect a mishap. The distribution of the signal lamps, their remoteness from the engine gauges, places them outside the scanning field of the instrument panel. It is evident, that if the pilot's sensations are not reinforced by immediate and accurate instrument information, a situation arises which causes confusion and extends the process of decision making up to inadmissible limits.

The cited experimental data allow us to formulate the following psycho-physiological recommendations:

- do not present the engine failure before the flight parameters match those displayed on the panel;

- the sensation about the flight regime disturbance should be confirmed not later than 0.5 seconds from its occurrence.

The importance of the referenced results means that in an emergency situation the flyer is a 'slave' to instructions for no longer than 20 to 30 percent of the time. The rest of the time is required for the informational interaction of mind with bearer of information. Character type, and success of this interaction are multi-dimensional, because of their probabilistic and individual traits. Individuality reactions manifest psychic laws, in particular, the understanding of the signal and not as much by the availability of a certain quantity of bits. It is paradoxical, but a fact that the importance of the signal itself is not identical to the danger or the seriousness of the failure of important equipment. This importance is determined by the psychic reflection of danger, which is shaped by the experience and full-fledged reflection of the situation, time availability, and sufficient space for action. In this connection, the aviation industry, as well as the flight instructors should take into consideration not only the operational, but also the psychological interaction of man with any emergency warning signal. My personal experience with the accomplishment of test flight experimentation has led to the following conclusions.

The emergency warning signal is optimal only when it promotes maintenance of the previous stereotype activity as well as the decision-making process. Thus, it becomes optimal when the immediate element in the activity structure performs the role of signalisation and steering simultaneously. The emergency warning signal functions under one mandatory condition: it doubles and assures not only the technical failure of the system but, at times, it organises and recruits the flying capabilities. Any information, in an emergency situation, should activate the psycho-physiological resources of the flyer, as well as his ability to make decisions.

The last postulate is especially important, because lagging in decision making is often related to the inability to actualise and convert the knowledge into actions. A flyer who realises an instant translation of 'unknown' into 'known', 'unexpected' into 'expected', 'improbable' into 'probable', can surmount and manage most tasks. The mind sees, hears, and perceives all together. We need to study and fully understand the mind. (Beregovoy G.T., Zavalova N.D., Lomov B.F., Ponomarenko V.A., "Experimental-psychological investigations in aviation and cosmonautics", Moscow, 1975).

I have analysed 'the dry sediment' of experimental investigations in order to openly and sincerely say – yes there are laws of flight, yes, there are laws of aerodynamics, and, yes, there are laws of the mind. The flyer, not knowing the laws of his (her) psychic activity, is simply dangerous; the flight instructor, ignoration laws of psychic performance, not including the relationship of psychic functioning into the everyday learning process, is doubly dangerous. If an aviation commander plans the level of flight mission complexity, without taking into account the human physiology and psychology laws, he may cause tragic mishaps to the flyer.

The most intimate secret of the flying man arises from the genesis of the wings, as they are not of metal, but of Spirit, doling out in a measure which is still a great mystery (a kingdom in the sky, grounded by rules, but unbounded by the love of flying). Please, ponder this.

CHAPTER 3

PILOT'S RIGHT OF ERROR: WHO IS GUILTY?

1. Introduction Human Factor and Flying Safety

The problem of flying has always been a key issue in aircrew survival, life span of aircraft and the equipment, technical and educational aids, research and development, ergonomic, clinical-psychology and social safety programs. A high level of responsibility commitment is a must at all levels of flying safety. At the same time, new aircraft technology, with its special difficulties and controversies, which could not always be successfully resolved, is the Achilles' heel of flying safety. In the following chapters, I will only touch upon some technologic deficiencies, and will discuss in more detail the history of the joint efforts by the constructors and the scientists, the physicians and the engineers, the ergonomists and the flight instructors, and the accident investigation teams in order to find reasonable compromises. Past efforts to determine the cause of accidents and, unfortunately, did neither influence the mood nor the motivation of the flying personnel nor their motivations. Every new aircraft brought joy, pride for the motherland and for himself, as well as self-confidence. But accidents always concern one man, not all the community. This is true when an isolated instance is of equal importance socially and as communally. Aviation mishaps, in all their drama, simultaneously promote the process of the social, the economic, the technical, and the scientific advancement for all those who participated in, the acquisition, the realisation, the adaptation, the training and the establishment of our country's defence. But the life of those, who sacrificed themselves in the name of the technological progress, demands an exceptionally sincere expounding of all advantages and deficiencies of this technology.

Therefore the problem of the flying safety and of the human factor needs psychological reconsideration. This should tell to the aviators, that this problem needs to be treated, for its humanitarian, and for its technical aspect. In our country, flying safety is subordinate to many state institutions. In the recent past, it was the State Aviation Superintendence, the Central Inspection of Flying Safety, the Services of Flying Safety, The professional, psychological and medical selection, the Aviation Medicine Department, the System of Ergonomics, to name a few. All these facilities work jointly, (in a coordinated manner), despite the continuous expansion of aviation operations, far beyond comfortable conditions for man, aircraft and the accident rate has been held at a sufficiently stable level: an average of 80-120 total accidents per year. The constant improvement of aircraft deserves special recognition. In the "Aviation and Cosmonautics" magazine of 1992 and 1993, all technical characteristics were reported for the entire available aircraft inventory for 1950 to 1993.

The concept based on the ergonomic human engineering approach to flying safety, directs the specialists to separate the two autonomous classes of accident causes, which differ principally on the direction of preventive measures. The main causes are related to the 'human factors', i.e., to the lack of constructive and operational characteristics of aviation technology, exposure to damaging factors and conditions of work, as well as to organisational errors. Timely prevention assumes first of all the maximum consideration of ergonomic specifications during research and development of new aviation technology and armament.

However, there still continues to be incomplete incarnation of ergonomic requirements, owed to which we have expanding list of professional harms, non-ebbing rate of erroneous actions due to ergonomic misreckonings in technology. And we are still concerned by the fact, that 80 percent of the total number of errors are related to defects, which were disclosed before delivery of technology in operational arsenal. As a result the error of some become the error of others. Yet, the flyer appears to be the only 'bearer' of the blunders, but the true source is found far from the flyer. I quote here especially for the independent investigators of aviation accidents, some rather remarkable data (see Tables 1, 2).

Please, examine these data carefully since here, for the first time, the error is openly demonstrated, long before the flyer's involvement. However, with training and experience, the number of errors sharply decreases. Naturally, man learns to evade danger, but who will 'pay' for endured moral losses and, at times, even the loss of life?

Table 1. Constructive defects of equipment in 4th generation aircraft as causes of erroneous actions.

NN	The matter of defect	STAGE OF DETECTION			The effects of deficiencies on flyer's activity
		Simulation	State aircraft tests	Operational use of technology	
1	Constructive deficiencies of throttle, impeding the activity with latches during shift of throttle from position of after-burning to position of small thrust rotation	+	+	+	Significant lengthening of throttle manipulation time in extraordinary flight situations
2	Unfavourable conditions of spatial allocation of control organs: switch toggles of photo-cinematographic machine-gun and toggles of shut-off faucets for left (right) engine;	–	–	+	Confusion of toggles, involuntary ignition of engine
	- landing gear lever.	+	+	+	Distraction of attention during take-off operation
3	Occurrence of glare from instrument panels, signal warning devices in cockpit during night flights	–	–	+	Impediments in spatial orientation
4	Auras luminescence of symbols on Head-Up Display and their insufficient brightness under high-levelled out-of-cabin illumination (poor sun-readable display capability)	+	+	+	Errors in flight parameter's information perception
5	Vertical speed indicator DA-200 gives information with significant delay	+	+	+	Interferences with prognostication of aircraft's spatial attitude and flight-path position
6	Informational panel of Flight Director Control System is poorly visible or blurred	+	+	+	Interferences during failure of flight director control system

The persistent errors and the aviation incident rate, due to insufficient stability and controllability of the aircraft, the workstation equipment, and informational receptions are influenced by aviation methodology documents where these miscalculations are poorly explained. Classes during flight training do not emphasise enough the direct attention on the exercises to learn features specific to the aircraft handling characteristics. Flight methodological documents of detailed construction, production, and ergonomic insufficiencies of specific manifestation in flight,

Table 2. Ergonomic defects of technology and flying safety, revealed in fourth-generation rotary winged aircraft.

NN	The defects, not established or missed on results of flight tests	The complaints of operational unit's flyers
1	The flight-bearing and glideslope-compass indicator [PKP-72] impedes the realisation of spatial attitude orientation of flyers	60-70% of flying personnel experienced significant difficulties in spatial orientation maintenance, in worst cases were registered the flight accidents, caused by spatial disorientation effects
2	Non-transparent elements of forward fuselage windscreen grid and their constructive arrangement under 20-40° interferes the spatial orientation of flyers during dense formation flight	The errors in flight formation alignment maintenance due to temporal loss of leader's position in field of view
3	Coarse violation of Russian Air Force departmental specifications and standards on intra-cockpit illumination	The predominant part of erroneous actions is related to mission of important signals due to excessive brightness of 9 instruments and panels
4	The flyer's seat is incapable to adjust on flyer's height in horizontal plane	More than 40% of operational pilots experience fatigue due to anthropometric mismatch of seat's and body's dimensions, uncomfortable working posture and constantly extended arm to rotating control lever

and the considerations of these deficiencies, in planing training drills, are important factors for improving 'flyer-aircraft' system reliability.

From viewpoint of engineering psychology and ergonomics, the established term 'reliability' still needs some refinement. For man, the reliability of the man-machine system is a prerequisite for goal accomplishment. Optimal man-machine interaction lays the basis for their potential unreliability. This potential unreliability is a systemic quality: it is inherent neither to technology, nor to man, but is manifested, as mentioned above, only during their interaction.

Aircraft "potential unreliability of human factors" can turn into substantial material and moral losses. I will cite some examples. Lately, everyone is extremely troubled with the rise in the accident rate; More than 60 percent of the mishaps have occurred <u>on aircraft in good working condition.</u> An analysis of this issue allows me to quote some factors, which promote aviation accidents independently of the flyer. In fact, 25 to 30 percent of the accidents have occurred due to spatial disorientation, 10 to 15 percent due to the ergonomic cockpit layout, 2 to 3 percent due to poor illumination and out-of-cabin panoramic view, and unimproved design of the ejection seat.

It is a well-established fact, that the flying profession has one unique feature, about which little has been written: the flyer must control the aircraft, for example the interceptor-fighter, with only 80~300 hours per year. Therefore, reliability of steering technology depends to a large extent depends on such factors, as training; the ground trainers must enhance the level of the flyer's preparation. However, today, their training efficiency remains still rather low, since the learning efficiency of flight simulators is not too high, for example, for landing approach – 0.7, for

extraordinary flight situations – 0.5, for visual flight rule conditions – 0.3, for takeoff conditions – 0.2, for aerial combat – 0.4.

Aviation accidents may occur on repaired equipment due to an unsatisfactory physiological-hygienic environment. Our experiments, the data shows that the performance level under exposure to noise, vibrations, and high temperature drops by 20 to 50 percent depending on the duration of the flight. We know that in fourth-generation aircraft the noise level exceeds the admissible sanitary level at 40 dB, vibration by 25 percent, the exhaust gas concentration around the aircraft is 12 times greater than the permitted limits. Therefore, it is not amazing that 80 percent of the flying personnel has been medically disqualified before reaching the age of retirement. Presently, it can be stated that due to insufficient ergonomic technology and social problems, we observe a premature ageing of the flying staff in comparison with the general population. I am relating these lamentable data because we need to recognise that aviation is an indivisible moral and technological entity. Consequently if in 1994 we still lack oxygen kit equipment KKO-15, (komplekt kislorodnogo oborudovania), naval flight rescue suit – VMSK (voyenno-morskoy spasatelnyi kostyum), pressure suit 'Flamingo', ground air conditioning systems, eye protection against laser beams, and against electromagnetic, non-ionising, radiation and some other equipment, shielding the brain and the body of aircrew members; we should blame our legislators, contractors, and flying safety specialists.

Investigating the physiological reactions of the human to flight factors, I came to conclusion, that he (she) has inherent natural limitations, which have influence on flying safety. This has been confirmed during in flight spatial orientation with time-variable changes of velocity vector and gravitational force, in work under conditions of vestibular and visual illusions, when the decisions were taken in 2 to 3 seconds. In the case of simultaneous perception of 3 to 5 parallel informational input channels, when the flyer moves his (her) eyes, (changing the point of visual fixation more than 200 times in 1 min), and when under exposure to high-sustained acceleration his (her) brain suffers from circulatory disturbances and hypoxia. For 1 flying hour of work, the flyer spends the physiological, energetic, and hormonal resources 5 to 6 times more than any person working at a ground transportation occupation.

A characteristic of modern aviation activity is its constantly growing negative influence of technological factors on human organism (noise, vibration, electromagnetic fields, accelerations), which cause in 5 to 6 years of professional exposure, health disorders, and occupational diseases in 30 to 40 percent of the flying personnel. To provide adequate flying safety we need to understand this social and economical importance. The fact is that, that professional reliability is, to some degree, acquisition and handing over of experience. Due to the high loss of professional health in the last 10 years, we have seen a stable trend of decreased flying longevity in military aviation personnel by 3 to 5 years. As a result, a first class fighter pilot (highest qualification in the Russian Air Force), will fly an average of not more than 5 to 7 years. I remind the reader, that the cost of training a pilot to fly the Su-27 fighter-aircraft, up to first class level of training reaches 50 millions roubles (price scale of 1993).

Generalisation of ergonomic deficiencies data in the workstation of flyer, of his survival and protective equipment, led Russian aeromedical scientists to predict the increased human factors errors in aviation accidents. For example, in third-generation fighter aircraft, at their combat-manoeuvring performances, the deficiencies in pressure suits could lead to loss of consciousness at a probability of 0.2-0.63, in the fourth-generation fighter aircraft, 0.6-0.7, and fifth-generation fighter aircraft, 0.9.

The human factor component of flying safety reflects the higher role of social aspects, affecting the mishap incidence rate. Among them are:

1. A growing gulf between leading technological advances in aviation and the delayed transitional training on newly acquired aircraft.
2. An intolerable gap between material investments in research and development and in the support of the human factor (flight training and conditions of private life). Presently the ratio of the gap is estimated to be about 7:3. As a result, we have a phenomenon of man's intellectual oppression by technology.
3. A dangerous drop in professional prestige. The flyer, as a vector of combat spirit, loses both, his social activity, and the confidence in his legal protection. In a dangerous profession, man is hurt when executing the right to opt for a moral decision in life-threatening situations, for self-evaluation of his capabilities, and for

the selection of professional training procedures according to his individuality

4. Insufficient technology development, in accident prevention and reduction, has led to a severe sequence of catastrophes of wide fuselage passenger aircraft, especially in densely populated areas.

It should also be noted, that many Air Traffic Control Centres employ former flyers, 30 to 40 percent of which are mediocre operators of spatial images and in poor physical condition. It must be noted that with the soaring of the flying workload in the Russian Military Airlift transportation, and commercial aviation, and the deterioration of living conditions of aircrews in the strategic and the tactical aviation, the mishap incidence rate has escalated. This may be attributed to poor hygienic comfort in the aircraft cabins. At the same time, I was very pleased to read the article by P.O. Sukhoy, Special Aircraft Design Bureau General Constructor M.P. Simonov (newspaper "NEWS", N3 (24110), dated January 6th, 1994: "The main piquancy in fighter-bomber Su-24 design – is its flight cockpit. It is roomy and as the commercial airline cabin TU-134 equipped with air conditioning. The aircrew may stand up, stretch the legs, limber up, lie down, pour from the thermos a hot cup of Russian soup-borshch – and go to ... restroom." I wish to add that General Constructor of P.O. highly appreciates his constant and reliable subcontractor – the Russian Air Force Institute of Aviation and Space Medicine. However, I am still troubled with the facts, presented in Table 3, which reflect the not so remote 'past' of constructors, as well as users of operational aviation technology [Table 3].

Since the aforementioned innovations were not adapted, the following reports were written:

- of all rotary wing aircraft crews killed in the Afghan war theatre, only 2 percent perished in the air, while 98 percent found their death due to complete lack of counter-impact protection during forced landing (in the American helicopter 'Apache' the same index for aircrew mortality, in emergency landings, is only 3 to 7 percent);
- due to the lack of eye protection against laser beams, the flyer is virtually incapable to acquire and master the new tactical procedures of air combat manoeuvring, especially in duelling encounters with use of laser range measuring devices;
- due to poor pressure suit protection equipment in the first 7 years operation of fourth-generation high performance fighter-aircraft the number of flyers with revealed health disorders rose by 12 to 15 percent.

In order to provide the psycho-physiological reliability of human factor the scientists of the Russian Air Force Institute of Aviation and Space Medicine – S. Bugrov, V. Doroshev, R. Vartbaronov, G. Stupakov, D. Gander, V. Usov, Yu. Kukushkin et al. – have defined the following solutions for flying safety:

1. The formation of the theory of the professional health of the healthy man which, in practice, is assured by the build-up of a computer-aided system of clinical diagnostication of the flyer's psycho-physiological reserves exhaustion levels, on the ground and in-flight conditions (S.A. Bugrov, V.A. Ponomarenko, V.G. Doroshev, Yu.A. Kukushkin, et al.). The establishment of the methodical restoration of the professional health parameters in pre-clinical stages of medical health control; in the "aviation regiment, aviation personnel resort (spa) centre, and aviation hospital" (G.M. Khorovets, Ye.S. Berezhnov, A.P. Ivanchikov, P.L. Slepenkov).
2. Use of personal computers to organise a typical consultation class for autonomous control by the flyer of his (her) professional health level, the dynamics of his (her) professionally meaningful qualities and his (her) sustained performance with the assistance of computer-aided teaching. Trainers for upgrading human psycho-physiological qualities, while assuring tolerance to interferences. A computer-based, automated system for the determination of a person's consciousness and workload performance, in-flight, under exposure to various extreme factors is also being considered.
3. Propose to the aviation academies didactic methods to teach and form professionally important qualities in aviation cadets, to accelerate the mastering of fourth generation tactical fighter aircraft.
4. Create an ergonomic advisory consultation system capable of predicting potential unreliability of the human factor, depending on the performance on the projected aircraft, and an early consideration of man's input at the earliest stages of development.

Table 3. The productional implementation of ergonomically oriented research and development work.

Ordinal Number	Type of product	STAGES OF TECHNOLOGICAL LIFE CYCLE (terms in years)			
		From draft project to experimental research and development	From experimental and development to experimental sample	State flight tests	Production mass (serial) and operational units
1.	Portable emergency survival kit for aircrews, operating in Afghanistan combat theatre	1984 - 1985	1985 - 1986	1987	Small-size experimental production series 1987
2.	Equipment for counter-impact protection of aircrews of rotary-winged aircraft	1984 - 1985	1985 - 1986	1987	Not implemented
3.	Anti-laser eye protection device	1981 - 1986	1986 - 1987	–	Not implemented
4.	KKO-15 (second series) High altitude pressure suit combined with anti+Gz-garment	1979 -1982	1982 - 1984	1984 - 1986	Not implemented
5.	Signal warning aircrews	1985	1986	–	Not implemented
6.	On-board flight-recorder for registration of medical and psycho-physiological parameters of aircrews	1980 - 1984	1984 - 1985	1986 - 1987	Not implemented
7.	Warning system for emergency escape from aircraft	1974 - 1982	1982 - 1983	1983	Not implemented
8.	Physical trainer for 4th generation aircraft crews	1981 - 1983	1983 - 1986	1986	Small-size experimental production series, 1987
9.	Laser landing approach guide system	1978 - 1980	1980 - 1982	1982 - 1987	Not implemented

Moreover, I need to stress, that, an important share of personal, human factor components, is not introduced from outside, but formed by the conditions and tools of the flying work, and the organisational system, and the substance of the professional training process. Therefore, the solution of the problems and of their psychological success, as the implementation in operational units of psychological tutoring aimed at the performance of missions in extraordinary flight situations, at methods of psychological analysis of errors and aviation accidents, at ways and procedures to develop purposeful flying capabilities is an important part of the complex flying safety enhancement and prevention of mishaps in aviation.

2. Scientific Study of the Flyer's Errors (pilot error)

There are many definitions of the word error but the encyclopaedias (Great Soviet Encyclopaedia, Dahl's dictionary, Ushakov's dictionary) give one common definition – blunder, slip, incorrectness; and the cause – unintentional, involuntary, fortuitous. The probability of error is always present in human activity aimed at the achievement of a predetermined goal, which is programmed early in the human brain. Inability to reach a goal, namely the result of a concrete action, is being generated by a cause-effect relationship, the solution of which will determine the content matter of the error.

In an aviation accident investigation, the flyer's error is always characterised as a result of human action, which failed to reach the desired goal. Hence, in an emergency, the flyer's error is used as an explicable cause of another much more complicated phenomenon – the widespread aviation mishaps. In other words, the error of the flyer, in the context of an aviation accident investigation, is considered as the final target, but not as the initial link in a chain of events leading to the emergency situation.

Earlier, an error by the flyer was classified as a 'personal factor'. The personal factor encompasses the emotional and the volitional qualities of the concrete personality, his (her) character traits, temperament, natural talents, aptitudes, tastes, habits, moral character, physical status, general and special training which might be related to the cause of the accident. The concept of personal factor, in an accident investigation usually steers the experts to the development of events, initiated by the flyer's action not by the man-machine interaction.

Aviation accident investigations have revealed an entire class of errors, which are manifested in healthy, able, emotionally stable, highly educated and trained flyers and aircrew members. These errors are usually called fortuitous because they can not be predicted. For example, changes in attention, concentration, inherent to all people, cause sporadic errors during processing of input and treatment of information. In contrast to the casual errors, there is a group of common errors. One of these errors is the so-called <u>provoked</u> error. I will dwell on those which are evoked by some conditions of the flying profession. It is well known that man, under some conditions experiences some impediments and sometimes commits errors. Such conditions entail:

- perception of signals under physical conditions close to the analyser's physiological limits;
- manipulation of control organs, built-up stereotype rules violation;
- reception of false, unclear information;
- time-sharing activity while performing a predominate task.

Under these conditions, common errors do occur. Let us view now the threatening factors which provoke an error. All specialists in aviation safety are concerned primarily to protect the working place of the flyer against <u>occasional and common errors</u>. The main deficiency of the fighter-aircraft MiG-23 is its small cockpit, which interferes with the flyer's professional activity. It measures of 90-120 cm in width and 210 cm in height. This presents difficulties for the flyer to work gears and with other equipment, especially, when the pilot dons pressure or winter suits and increases the probability of errors when working on the toggles, levers, etc.

The asymmetry between the eye position and the line of vision (MiG-23) can not be corrected by adjusting the seat. The height adjustment of the seat is only 100 ± 50 mm, while the difference between height of the flyer's eyes at the minimum or maximum seating height is 176 mm. This often leads to a hidden cause of the flying personnel errors – landing prematurely, or landing by overshooting the touchdown point, high or low levelling off. These errors were first rated as 'incorrect attention', i.e., the blame was placed on the flyer.

Present aircraft do not comply any better with the Air Force specifications and the government military aviation technology standards concerning the distribution of control levers and organs in the cockpit. The comparison of the distribution of the control switches in the cockpits of fighter aircraft, MiG-21 and MiG-23, revealed substantial discrepancies between them (see Table 4).

This lack of conformity has caused remarkable interference in the flyer's performance, especially in the in transitional phase – 27 percent of the flyers committed errors and 15 percent could not even find the switches, and were in a state of complete bewilderment. The lack of cockpit layout standardisation of the instrument panels in these two aircraft caused attention stress.

Leaving aside the detailed description of the professional features of the pilot's performance, it should be noted that the working place of the flyer is conducive to error making, thus decreasing man's performance reliability. The Institute of Aviation and Space Medicine, jointly with the Special Design Bureau named after Mikoyan, (Special Constructing Bureau of Aviation Testing Institute and Air Force Engineering Academy, named after Zhukovsky) have worked out a new distribution pattern for the instrument panel in the MiG-23 fighter-aircraft cockpit. Table 5 shows the data obtained with simulators.

(These data were kindly given to author by the Russian Research Scientist professor Yu.P. Dobrolensky, and Chief investigator of the project at the Special Design Bureau named after Mikoyan, Doctor of Science Technology Yu.A. Yanyshev).

Much of the obtained data was used to modify subsequent series of MiG-23 fighter aircraft. The most dangerous errors were revealed during aerial combat manoeuvre operations in sorties and aerobatics – loss of velocity as a result of dragging down to minimum speed at the acceleration level of Ny=1, or due to excessive pulling of the control stick during manoeuvres at Ny>1.0. Officially, the error was acknowledged by the flyer, which in time deficit conditions could not manage to track the acceleration indicator, but used only non-instrument information (+ remote: proprioceptive afferent input signals). The flight errors were usually related to difficulties in keeping a constant visual control of the angle of attack, velocity indicator, acceleration indicator which facilitated the spatial scattering of enumerated visual displays. A concomitant cause was recognised – absence warning signals of pre-stall regime, approaching of zones between clearances and limitations as on target value, and time of going out beyond operational limits. In order to better understand these errors, let us discuss in greater detail aircraft steering.

Professional analysis in a unified time-referenced scale of instrument displayed indices, as eye-fixation movements on visually picked up indicators and the quantity of control stick movements has shown, that in a predominant number of flying regimes, the frequency of changes, in displayed indications, is much higher than frequency of the eye movements and visual fixations on the displayed flight parameters. This means that not all significant flight information has been perceived by the eyes. It suggests that, during aircraft steering, there is a 'two-staged' regulation of control movements – the locomotor action is 'triggered' by a visual signal, but his fine adjustment and correction is owed to proprioceptive control, i.e., to the participation of mechanoreceptors of muscles, ligaments, joints, and vestibular apparatus. It has been established with experiments, that 20 to 30 percent of the time, the movements is performed without any visual control, namely, the movement is realised without instrument signals. This conclusion is of great importance, for the non-instrumental information – angular and linear accelerations and their derivative values, the muscular efforts for control stick displacement, noise, vibration, etc., comprise (though perceived subconsciously) a significant flow of information which is the so-called "sensation of the aircraft".

At that time, we conducted studies of the sensation threshold for angular and linear accelerations, control stick muscular expenditure, as well as the temporal characteristics of the flyer's work depending on the duration of the exposure and the onset rate. It suffices to say, that the scientists at the Institute of Aviation and Space Medicine have carried out special investigations, which proved, that the threshold sensations of the flyer depended upon his flying experience. For example, the accuracy in creating and maintaining acceleration during a turn was, among flyer-snipers (highest rate of flying qualification), ±0.3 Gz; among first-class flyers 0.3±0.5 Gz; among second-class flyers 0.5±0.8 Gz; and among third-class flyers 0.8±1.0 Gz (R.A. Vartbaronov).

Table 4. Disposition of some control organs and levers.

Lever	Arrangement of levers in two types of fighter-aircraft	
	MiG-21	MiG-23
Switching on fire-extinguishing system	In lower forward sector of left vertical panel	Upper part of left vertical panel
Fuel duct cutting off faucet	Centre of left vertical panel in front of throttle	Upper part of left vertical panel above throttle
Engine initiation in flight	Lower part of left vertical panel	Upper part of left vertical panel
Dropping of wing-fixed fuel tanks	Lower part of control stick	Centre part of head-down instrument panel
Release of drag parachute during landing	Left upper part of head-down instrument panel	Upper half of left vertical panel in front of throttle

Table 5. Comparative estimation of two versions of instrument panel layouts for flight information presentation and control organs location.

Criteria of estimations	Serial instrument panel	Proposed instrument panel
Deviation in height from demanded altitude in flat and level flight, while working with boresight, m	240	150
Interval times or gaps in spatial orientation control on instruments, while working with boresight, s	1 - 12	1 - 3
Time expenditures working with manual controls, s	2.2	1.2
Probability of failure detection on control displays of engine group (fall of rpm)	0.3	0.8
Time performance delay additional task, s	2.2	0.8
Physiological tension indices on cardiac rate frequency (beats per second)	81	76
Subjective estimation by the flyer of control organ's location discomfort percent	90	2

Table 6. Characteristics of the use by the flyer of non-instrumental signals in fighter aircraft MiG-21.

Class of flying preparation	Number of observed pilots	Total flying hours	Prefer to steer on "aircraft feeling" in %	
			Aerobatics manoeuvring	Combat
1	28	2100	90	90
2	36	1300	55	100
3	34	500	76	95

Characteristic data were obtained with aviation cadets during flight training of vertical manoeuvring evolutions. It demonstrated that as skill acquisition and experience progressed the share of visual control of flyer, on the instruments and the displays, has lessened by 40 to 60 percent while flight precision enhancement increased. The same pattern was observed during flight training on helicopters – the less experienced pilots used 80 percent of their available time to watch instrument and display controls; moreover with one eye fixation duration up to 5-7 seconds, while the highly experienced flyers shared only 30 percent of their visual attention time. In all experiments, the flyers and aviation cadets heeded especially the non-instrumental signals. Below is the data of the experiment performed by I.A. Kamyshov and A.A. Vorona (Table 6).

Based on these experimental data, the greater the experience, the more the flyer relies on non-instrumental cues in steering the aircraft. The presented data relate merely to the flyers, who flew earlier only the MiG-21, and acquired good flying skills of automatic reflex aircraft steering performance.

The ability of the flyer to use, at the subconscious level, the non-instrumental signals for correcting attitude, determines the psychological essence of "aircraft feeling". As to flying the MiG-23, a somewhat different picture was revealed. (Table 7).

Table 7. Percent distribution of the visual attention of the flyer on cockpit displays and out-of-cabin inspection during performance of simple and complex tasks on a MiG-23. (A.A. Krivonos data.)

Aim of vision	Aerobatic manoeuvres		
	Loop of Nesterov	Semi-loop	Vertical climb
Out-of-cabin	49	53	49.6
Cockpit	51	47	49.4

*Footnote – Only first class pilots participated in these experiments.

The main displays in this type of aircraft are speed and altitude gauges, which use from 47 percent to 71 percent of the flyer's visual attention time. The commander's flight display and vertical speed indicator occupied about 17 to 40 percent of the flyer's total instrument visual attention time. The duration of one fixation of the eyes on the display is around 0.4-1.1 seconds.

During out-of-cockpit viewing the flyers fix their eye mainly on the horizon and the left windshield. And during the performance of the oblique loop manoeuvre, the displays are checked from 30 to 70 percent of the time. Only one half of the flyers check the accelerometer, for 1 percent of the total instrument visual control visual attention time. Time interval between out-of-cabin and to visual control and head-down display gazing varied from 0.8 to 1.5 seconds.

As the presented data shows, the experienced test pilots are busy mainly by handling of the instruments. It should be noted that flying on an aircraft of the previous the generation, UTI-MiG-15 (training fighter MiG-15-UTI – uchebno-trenirovochnyi istrebitel), the same aerobatic manoeuvres require only 40 percent of visual control time of the head-down instrument, while later, the same manoeuvres, on the MiG-21 demand a visual control of only 20 to 30 percent of the flyer's total time. It should also be noted, that in sorties with aerobatic manoeuvres (MiG-23) the flyers made a great deal of mistakes for not maintaining proper speed, angle-of-attack, acceleration, altitude regimes. The steering of this unsophisticated fighter aircraft, as mentioned earlier is plagued by the "the control stick over-pulling phenomenon" stipulated by incompatibility laws. These laws govern the changes in efforts and in amplitude of the control stick movement in a unit of acceleration (the designers of the MiG-23 control system have miscalculated the technical parameters of the aircraft is controllability and stability). From 1970 to 1979, the operation of aircraft of this type had 25 mishaps due to stalling during takeoff level flight and in performing complex manoeuvres.

In more than 50 percent of the cases, mistakes were made by 1st and 2nd class pilots. Analysis of sensitivity thresholds and psycho-physiological perception laws non-instrumental cues supports the fact that this is a typical example of disregard for the human factor in the planning of the control system. In fact, depending on the speed of these aircraft, altitude changes according to effort and amplitude changes of the control stick movements per unit of flight acceleration. Moreover, with increased acceleration, the, the human efforts are decreased, which contradicts all the laws of psycho-physiology. Although it is well known, that efforts on the control stick should strictly correspond to psycho-physiological laws during flight steering, the pilot must receive the information (sensations) about effort changes from the control stick with an equal degree of accuracy.

A psycho-physiological study, performed by scientists M.I. Radchenko, F.A. Zubets et al., has revealed that characteristics of stability and controllability of the aircraft should be considered, first of all, by taking into account the physiological qualities of sensations and the perceptions of the flyers. In the longitudinal axis of aircraft's control, the quantitative characteristics of the aircraft controllability should be coordinated with threshold sensitivity to the above-cited cues, adjusted proportionately to value and time with the direct feedback information from the control stick and the acceleration. According to their calculations, the optimal relationship of the effort value (dp) and of the control stick movements (dx), per unit of generated acceleration (dn), should be as following:

For dp/dn in the range from 2 to 6 kgs/unit =

$$\frac{\text{threshold of effort sensitivity}}{\text{threshold of acceleration perception}} = \frac{(0.2 \div 0.6)\ \text{kgs}}{(0.08 \div 0.1)\ \text{unit}} = 2\text{-}6\ \text{kgs/units}$$

For dx/dn in the range from 20 to 40 mm/unit =

$$\frac{\text{threshold of movement perception}}{\text{threshold of acceleration movement}} = \frac{(2.2 \div 3.5)\ \text{mm}}{(0.08 \div 0.1)\ \text{unit}} = 20\text{-}40\ \text{mm/unit}$$

If dp/dn, dx/dn are less than optimal values, then the flyer, stabilising the aircraft with the required accuracy of 10 to 15 percent (transfer from admissible to critical angle of attack) can not accomplish it, since he does not sense the change of controlling movements, which are proportionate to change in acceleration. If dp/dn, dx/dn are greater than optimal, then the flyer, performing the analogous task, does not feel the on change in acceleration in response to the control stick movements. Coordination of the movements is realised, in this case, on much higher level and with less effort precision. Our flyers have encountered this situation during the transition to the MiG-23.

Thus, a takeoff with an angle of attach attended by a stall (high acceleration), proliferated by incongruity between contractor characteristics of aircraft in the longitudinal control channel and psycho-physiological capabilities of the flyer (differential thresholds), which impeded the feedback to the flyer of the force applied to the control stick. This suggests that initially the flyer could make a mistake due to an incorrect estimation of the overall flight situation. But later, the error was repeated at the expense of the contractor's defects in the steering control system.

In the 1970s, we had to minimise the weather ceiling for the MiG-23 landing approach from 250 m (lower edge of ceiling) x 3000 m (visibility on slanting distance), originally to 200 x 2000, and further, from 150 x 1500 m, down to 100 x 1000 m. Special experiments have shown, that the highest reliability of the flyer's performance under these conditions is guaranteed only by an autopilot landing approach regime. At the same time, the lack of an on-board warning signalling system, which displays to flyers the failures of the automated control system for landing guidance sharply reduced the reliability of aircraft control system in the regime of flight-path steering. The main quantitative indices of the flyer's reliability at non-signalled failures are shown in Table 8. From these data it follows that the absence of signalisation creates direct threat to flying safety.

The data presented in Table 8 show that the flyer's errors may be caused not only by a poor professional training, but also by construction and by technical deficiencies. The obtained experimental data were applied in all subsequent modifications of the MiG-23; cockpit layout, creation of system for reciprocal connections, system of active flying safety, failure signalisation, and warnings of the autopilot's failed control channels.

The ergonomic explorations have contributed a substantial amelioration of the flying safety of the world's best aiming complex 'Sapphire-23', (at that time), the mass-produced fighter-aircraft MiG-23, characterised with the best control automatisation. These experimental studies have laid down the foundations for design of the most comfortable cockpit for fighter aircraft of the last 30 years – the cockpit of the MiG-29. The cooperation with aircraft Special Constructing Design Bureau named after A.I. Mikoyan, paved the way for the experimental aviation engineering psychology and ergonomics, which latter became a multi-staged ergonomic service organisation in the Air Force and Aircraft Manufacturing Industry Ministry.

Pioneers in experimental engineering and psychological investigations in the creation of aircraft and the objective evaluation of the flyer's errors are: A.V. Minayev (later promoted to Deputy Minister of Aircraft Manufacturing Industry); Major Generals of the Air Force test pilots G.A. Sedov, A. Kolchin; Doctor of Psychology N.D. Zavalova; leading test-engineers I. Vlasov, I. Krestinov, K. Leontyev, V. Nosov, V. Chekmasov; Doctor of Technology Yu.P. Dobrolensky; Candidates of Technology

Table 8. Characteristics of flyer's activity during failures of autopilot control system.

Regime of control	Types of failures	Number of failures	Probability of autopilot failure detection	Time of auto-pilot failure Recognition	Probability of autopilot failure recognition	Probability of reliable landing
Autopilot control	Rapid	119	1.0	$\frac{0.6 - 1.3}{1.1}$	0.21	0.94
	Slow	117	0.82	$\frac{8.5 - 61}{29.6}$	0.51	0.76
Director control	Slow	138	0.69	$\underline{15 - 63}$	–	0.68

test-pilots S.A. Mikoyan, G.F. Butenko, V.N. Adamovich; test-pilots V.Ch. Mezokh, V.I. Tsuvarev, V.Ye. Ovcharov, V. Migunov; pilot-engineer Ye.P. Kolomiyets; Air Force leading specialists O.K. Rogozin, Ye.V. Tyorkin, V.V. Somik, N.I. Grigoryev, A. Ayupov, A. Pankratyev, and S. Nazarenko. I also wish the mention the support of the engineering and psychological contributions to the flying safety and aircrew's reliability assurance of the Flying Safety Services (N. Rubtsov, P. Bazanov, Yu. Kulikov, A. Tarutko, P. Ryzhov, A. Yolkin, I. Mashkivsky, V. Bocharov, and others). It is with great pride that I acknowledge all of they, since their efforts and those of their co-workers, have saved many lives.

3. Personality of the Flyer as the Foundation of his Professional Reliability

Personality represents not only societal consciousness, but also the proper Spirit. For the flyer, personality begins with the need of freely choosing his destiny to overcome his ego and prepared to face risks. Conscience, altruism, and willpower are the first steps in reaching for morality heights. Thus, the personality of the flyer begins with overcoming of self and only then, its emotional capacity is transformed in accordance with the social and professional tasks. Only after this is understood, will we be able to comprehend the inner universe of the flyer, and to explain his behaviour.

The psychological inner world, which changes and develops his 'ego'[1], is determined by his love to fly, by the emotional sensation of a free Spirit. The state of a free Spirit is highly appreciated in aviation. Here rests the historical roots of the human flying profession and of democracy as a form of social existence. Our society should be aware of the fact that condemnation by the military aviation community of the August 1991 failed coup, to use force, is not as much a political demarche as natural counter-action to the immorality and the depravity of some politicians.

The inner universe of the flyer contains not only the emotional sensations of a free Spirit, but also its own pragmatic personality under the influence of technology. For the flyers, the aircraft is not merely an 'iron horse', it is a living partner and, for specially gifted individuals, a second 'ego'. Not without reason, many flyers 'physically sense' the wings of their aircraft as an extension of their own arms. Why is it important to know this? Because these peculiarities should be taken into account aviation pedagogy and psychology, since aviation technology gives birth to its own style of human relations, even its own morality.

So, the second-generation aircraft technology, (jet aviation) had demanded remarkable abilities from man in the field of the motor-sensory activity, coordination of movements, spatial orientation, strong willpower qualities. In earlier times 'the foe' was 80 percent 'tangible', and visible, the single combat engagement required nerve and physical energy expenditures. Psychologically, the flying community was closely knit, socially unified. Confidence in one another was built not so much on personal like, as on knowledge of other's professionalism, and achievement of mastery. Another fundamental psychological feature was fling ethics as a system of interpersonal relations – the coward, though not being condemned publicly, was silently rejected. And lastly, aviation technology was then peculiar to professional group activity (formation flight by squadrons, regiments) with the backing of the high personal reliability of the commander. In poor weather conditions, the commander usually took off first and landed last.

What was the impact on social psychology by the supersonic jet aircraft of the 3rd, 4th generations? First of all, a forcible attrition due to health, but not to personal qualities and flying abilities. Many competent and deeply committed Air Force flyers were left behind. The mid-sixties saw the beginning of serious social illnesses in aviation – technocratic levelling of flying skills, shift of experience priorities, in permanent values of a dangerous profession (staffing trimming policy of aircrew rejuvenation. A plan was established to train class-rated flyers with all the formal attributes. It is difficult to invent a greater absurdity than the so-called "socialist rivalry" to obtain a 1st class flying qualification. Social hypocrisy and social immaturity became a heavy load for the pedagogic process of a spiritual training. All these changes were compensated by enhanced aviation technology reliability and by improving ground control equipment and services. With the introduction of flight automatisation, improved radar control systems, the aircraft could steer to a landing approach with much less danger. The psychological complexities of flight missions were averaged, which enabled to use a greater

[1] Tr note: The author does not refer to Freud's "Ego". In the Russian text he uses the letter YA, which, translates literally into English, as "I".

number of mediocre flyers. Little by little they became dependent on the 'ground' personnel. The training of the highly qualified professionals gradually precluded the requirements for the highest personal mastery from exceptional flying skills, and that certain spiritual ego. As an example, I would like to cite some episodes from my regiment's life. Considering that from 1955 to 1960, our regiment had been often alerted to intercept aerial space violators in any weather conditions, the squadron deputy-commander, V. Fyodorov, trained the subordinate aircrew personnel to perform aerobatics, at night and in the clouds, on the trainer UTI/MiG-15. It is difficult to believe this, but I have witnessed it. These professionals were the first in line to be removed. Figuratively speaking, there was a need for first-rate flyers, but not performers. However, at the beginning of the '80s, the new aviation technology again demanded more mental aptitude of image and abstract thinking, flexibility of skills and an 'alert' central nervous system. This sharply increased the level of social and moral responsibility of aircrews, because the substantially increased range of aviation, thus increasing the demands of the operational and tactical strategies of interaction with other forces. And lastly, the 4th generation aircraft restored not only the requirement of a perfect physical health, but also mental talents, and a high psychophysical endurance.

And now we should openly acknowledge that progress in aviation technology has surpassed the human potential. For these reasons, flying safety did not plummet so much because of flight discipline violations, but mainly due to professional incongruities of the aviation technology complexities. How were we to achieve professionalism, if in the '70s and '80s more than 80 percent of the flight instructors were former aviation cadets with mediocre flying abilities, more than 40 percent did not care to be the flight instructors, and than 70 percent of the graduates had no aviation pedagogic aptitudes? In time, the situation became hopelessly embittered: total flying hours were reduced due to aviation fuel shortages. In all frankness, the matter was sometimes plain cynicism: "a drop of fuel was dearer than a drop of the flyer's blood!"

This is the grim truth of our present state of affairs and the pedagogic neglect of our professional training! However, only one circumstance continues to save the situation from further aggravation – the dangerous flying profession did not permit to lower the plank of professional training beyond the danger level, or that of life, though all that does not concern the flyer's individuality.

But currently, we are living in other times where society strives toward a free and democratic society. This means that in the foreseeable future, we shall be educating new people in a new aviation. But to restore the trust of the servicemen's parents to the shaken prestige of military aviation may be possible only by building spiritual and societal bridges between schools and Air Force academies. They should be based on the principle of continuity, which means the conservation of a common spiritual space. Hence, the current process of flight training should be impregnated with educational imperative and impetus: ignorance, weakness of spirit and body in the flying profession spell not only mission breakdown, but death and loss of aircraft.

Proceeding from the forthcoming tasks of deep reformations and changes of army life, I wish to mention some proposals concerning socio-psychological didactic flight training practices ranging from special boarding schools to centres of flight retraining.

1. Create for the dangerous profession specialists' activity a social climate which can be conducive to the realisation opted by one's own free will to a right to risk.

2. Give a psycho-physiological training of essential value, even excellent aviation skills such as flying an aircraft, and excellent physical training and automated competence, are insufficient for ensured human factor reliability. There is a need for a special psycho-physiological training subordinated to the formation of special new functional processes of psychic and physiological activities. These processes must guarantee a strong adaptability of the flyer's body to exposure of time-variable flight accelerations to estimate, once more, space and time, to instantly correct the distorted perception of the spatial attitude, have the mental skills to work various spatial coordinates against the background of complex interferences, to concentrate attention, simultaneously, on 2-3 time-sharing highly motivated mission tasks etc. Currently, we are simply ignoring these needs because more than 80 percent of the aviation accidents are ascribed to

non-compliance of rules and regulations. All this, because the focus of the aviation accident investigations is not man but the result of his performance. If we really wish to liberalise the civil rights in aviation, we need to start raising the level of our rights, our knowledge of the psycho-physiological peculiarities of those, we are going to train and to teach. This relates to a technical policy problem removed from pedagogics, since before technology starts to change qualitatively, there will be strategy changes as well as in the philosophy of life, and also new goals.

New goals, as the use of aviation in the national security forces, in operational, tactical or strategical tasks and operations must, first of all, change the personality requirements of those who will accomplish these goals. Conversely, it appears that what we see now, the technology is smarter, more complicated, more dangerous and much higher than the level of our professionals. For this reason, in evaluating the contemporary state of education and upbringing, we should change the old attitude and place, at the centre of flying safety, new qualitative education and training. In this connection, I venture state that at this junction of new pedagogics and new psychology we need to find the legal right to enhance the professional readiness of both the civil and the military aviation.

3. In my opinion, scientific pedagogics and psychology, have an historical mission: to start a radical, ethical health reinforcement program in aviation collectives. The results of the latest investigations have demonstrated the main reason for aircrew unreliability is a lowered social activity of the flyer. Errors in decisions are not only due to professional unpreparedness, but also to moral immaturity: conformism, submissiveness, lowered self esteem, "lame willpower", and the syndrome of "protecting others." Ignorance amid aviation commanders, in the field of socio-psychological relationships and rules of aircrew's behaviour, has resulted in social and legal vulnerability in the dangerous professions.

Consequently, the reformation of the social consciousness and the aviator's professional training must be a priority legislation for education. The strategy of the new educational concept is the principle of training continuity. For this aim, it is necessary to create, without delay, a practical scientific centre for aviation methodological technology, didactic innovations for the training of flight instructors, pilot instructors placing emphasis on personality and intellect.

In aviation, (military especially), there is a good old tradition of respectful relations to high-ranking authorities, and this is not a trimming, but genuine tribute of respect to experience. This means that those with more experience can demonstrate to the less experienced how to behave in the sky. I am referring to violations of flight regulations. This is also a learning session, and in this case, rank plays no important role. The scientists have carried out a special sociologic poll of aviation trainee's behaviour in situations where the elder in rank violates the rules of flying safety. Three questions were asked: How did you behave yourself, and how should you behave? What did you feel? By what regulations should you be guided in such cases?

Here I cite excerpts of the answers of quizzed flyers. The replies are interesting. You be the judge.

Pilot No. 1. – "Typical sortie on trainer UTI-MiG-15. Upper edge of cloud ceiling 800 m, flight altitude 3000 m. The flight instructor entered in and accomplished rolls and semi-loop without warning. I had tried to complete the manoeuvre started by the instructor. But having received an order from the instructor, and after checking the altitude, I stopped steering to resume flight after the semi-loop. At first, I felt some fear, but took the decision to react instantly. I controlled the flight-path and was ready to correct the errors. I thought, how will this be judged on the ground? I was amazed at the flight instructor's irresponsibility and carelessness. I could never make such manoeuvres, but, judging by his behaviour, he knew that he would not be reprimanded."

All official documents (Manual on Flight Operations Fulfilment, Course of Combat Preparation, directives, circulars) categorically preclude the violation or alternation of pre-planned mission task.

Pilot No. 2. – "Over middle radio beacon, we came out of the clouds and made a go-around manoeuvre for repeated landing approach with repeated touchdown on runway in reverse to

takeoff course (backcourse). The flight instructor-inspector had reported to the ground controller that we would fly glideslope trajectory and, over distant radio beacon, we should go-around, and I asked him to switch on radio station for takeoff bearing. The ground control centre officer forgot to switch off the radio station with the previous landing bearing. When I passed the distant radio-guiding beacon, the inspector had voiced to the ground and ordered me: "Go lower to middle radio beacon". At a height around 150 m, I detected the failure of the bearing needle indicator and informed the instructor. He answered: "Go, go down otherwise the ground controller will call us imbeciles". I had continued to go down, instead of around. Just before the middle radio beacon I detected the failure of the glideslope needle indicator and both needles dropped to full mechanical stop. The inspector had thought that we were flying above the glideslope trajectory, and sharply pushed the control stick. I pulled it with jerk, as I had no fear. The aircraft levelled off. Just then we saw at eye level the aerials of the middle radio beacon and we penetrated the clouds with a climb. I understood what the intention of the inspector to demonstrate "the higher class of pilotage" could have cost me. His error, my passivity, and I felt very bad...Luckily all finished well."

I was deeply upset that I allowed myself to be oppressed in this situation, which could have cost me my life and the unhappiness of all of my dear ones."

Article 588 of the Flight Operational Manual (1978), requires a pilot to perform a 2nd go-around manoeuvre in cases when the flyer, being guided on landing approach at the minimum permissible altitude, does come out of the clouds and does not see the ground This rule is also in the administrative rules and recommendations of the Air Force Headquarter Command.

Pilot No. 3. – "In 1974 during a cross-country flight, one the accompanying instructors performed a barrel roll around my aircraft at a distance of 15 to 40 m radius. I was horrified. I did nothing. However, I believe that such situations are useful, and should be performed periodically in order to estimate the ability of the flyer to control life-threatening situations. The document, prescribing the rules of flight formation performance, is the Flight Operations Manual".

Pilot No. 4. – "During joint flights with the Norwegian Air Force aircraft (P-3 Orion) at separation with sufficient altitude reserve, they banked at virtually 90° and, with, a sharp loss of altitude disappeared from view. This manoeuvre in a combat situation has distinct positive advantages, but currently it is estimated as an aviation incident, because its performance trespasses the maximal permissible operational banking limitation. When I once was a co-pilot, the commander-instructor demonstrated it to me. I helped him steer at takeoff before maximum acceleration is reached. I am aware that such behaviour is air hooliganism, but we should learn to fly as our potential foes".

Pilot No. 5. – "During terrain – following training in 1978, the squadron commander, took the control stick in his hands, flew to a height of 50 m over a densely populated area instead of over the runway. I did not interfere despite the coarse violation in flying safety regulations; I thought it would be improper to discuss the conduct of my boss. Later, I came to the conclusion that it would have been reasonable to mention not to fly so dangerously at extremely low altitudes."

The presented materials need some comments. Such cases are not exceptional. They suggest that both elder and younger crewmembers need to be taught ethical demeanour, dignity, and mutual respect. Let us analyse, from the psychological viewpoint, those personality qualities which could help us to understand the motivation of certain hard to explain deeds that lower flying safety. A more or less generalised characteristic of the flyer's personality is the rather broad notion "professional culture". Under the term of "professional culture" we understand the need of the flyer for constant knowledge growth and sophistication for the creative enrichment of his personality and of his flying mastery. It is needed in order to attain the highest levels of professional activity, to satisfy his spiritual and social requirements, to meet the moral principles of our society, and the interests of the aviation community.

How is the professional culture of the flyer formed and how is it related to flying safety?

An adolescent – school graduate – comes to Air Force Aviation Academy with thoughts of flying. His dream to takeoff fills not only his consciousness, but also his heart. All is perceived

and even controlled by noble high spirited, emotionally tinted sensations. The strong willpower forms the character of the flyer. Under watchful eyes of his comrades, of moral supervision of his tutors and instructors, personal activity is generated to achieve the best professional qualifications. This characterises the personality as a whole. Naturally, the medium of openness and the constant competitiveness create the objective premises for excessive self confidence – "all is legal." Thus, ethic education, from its initial stage, aims at flying safety. New moral orientations and values are elaborated whereby "I want", "I wish" are replaced by "I must", "I should", when intentions are dictated by the demands of aviation service laws. We are concerned with the formation of the highest ethic personality qualities and of the highest sense of responsibility: to understanding that independently on my wishes all the members of aviation community are responsible for my error. This is a first step to conscience awakening, which holds the bold flyer within the frames of his duties based on the awareness of his own true flying capabilities.

Therefore, the first stone in the foundation of the professional culture of flyer is his conscience, and his responsibility to those who are sending him on the flight missions. The flyers must fully comprehend that in the case of non-observance of the flying safety rules, including the exceeding of his own personal capabilities, the aviation community will view it as a violation of moral demeanour, or simply as immoral in relation to the collective norms. And this occurs not only because of the wish of ranking authorities, but also because the demands of the high-moral social structure of the aviation community life.

The second stone in the foundation of the professional culture is the occupational and personal reliability of the flyer. This quality consists of intellect and creative activity. How can they be combined using strict rules? This is a natural gift of the commander-trainer, aware that legislation is a known path, but creativity is a 'unknown'. As I mentioned earlier creativity is formed even in elementary performance, as sensory-motor acts during instrument flight. Actually, keeping the gauge needles in a predetermined regime is not 'tracking them', but anticipating potential changes in the flight regime, so as to react in an appropriate manner.

Therefore, the mind of the flyer is constantly in the prognosticating and visualising possible near future events. New knowledge, based on prognostication images of foreseeable events, is the psychological foundation of his readiness to make decisions. Scientific analysis of the flyer's behaviour in an emergency situation has revealed, that psychic regulation of actions occurs with the help of certain thinking strategies arising from the flight images and not only from the instrument display panel. Lightning-like decisions have been reached not by way of sequential selection of potential combinations of signals, but through instant option of key signals and intrapsychic unfolding of the image of forthcoming actions.

In aviation pedagogics, the flying activity has been viewed for a long time, as a chain of automated operations, but the process of instrumental information perception as a passive reflection of the instrumental analogue of flight. To estimate the intellect's role, the thinking processes, the image prognostication of future actions we required additional research efforts. Consequently, the creative performance based on professional skills, was beyond the focus of our possibilities. At the same time, the creative component of the pilot's flying activity is nothing else but the professional readiness to act in an emergency by opting one correct decision amid many potential choices. The intellectual essence of these actions requires that the flyer's mind organise the chaotic signals into a regular pattern. Creativity, from the viewpoint of flying safety, warrants the resources of the flyer's reliable actions, his professional vigilance, and the high level of his personality qualities. But, unfortunately, not all is well, and I wish specially to stress that the formation of the occupational reliability depends not only on flyer himself.

What is the problem? First of all, lack of scientifically corroborated criteria of the flyer's readiness to action in an emergency situation, which may occur in any flight. Sometimes this helps the flyer to unexpectedly recognise that he is not ready to act in a concrete dangerous situation; he is not ready to control it. Thus starts the "nobody is guilty" idea. I will discuss this in more detail in following chapters. Now I shall only note that insufficient understanding of the human psychic organisational nature of the involuntary actions leads to teaching simplification. The psychological essence of simplification consists in the fact that man not always acquires the skill to make autonomously decisions in an unforeseen situation. In aviation practice, this situation is often aggravated by the fact that the decision is taken collectively, through the interpersonal relations and

agreements of crewmembers. However, training sessions unusual flight situations are often carried out by only two persons in the cockpit. In actual flights, voice communication includes ground flight control personnel who are not always aware of the actual course of events as they are perceived by the flyers. Hence, instead of oral commands, we have a 'speech cocktail'. Evidently, teaching and training a class about extraordinary flight events should include the simulation of problem situations in real time scale for all links in the flight control system. The psychological training should include not only the interaction but, and this is more importantly, the teaching of all ground control personnel to recognise the situation, as it is perceived by the flyer onboard the aircraft. Only a unified representation of the emergency situation can help the flyer to reach a decision.

Creative activity must be a sustained vital stimulus of the flyer, as for 20 to 25 years of his professional life, he will cope with a continuous updating and acquisition of new aviation technology. The psychological feature of the process concerns the fact that the previous flying experience becomes insufficient for the transitioning to the new generation aircraft. This triggers the powerful moral attitudes of the personality, since a successful overtaking by the flyer of the new aircraft changes his self-esteem, raises his social status and the flyer is elevated to the level of social tasks solver.

The moral position of the flying safety support system in the process of training consists of not denying the lawfulness of 'game rules', i.e., the legal and normative and establishments simultaneously become the zone of creative spiritual growth. The lack of such drive and the loss of interest for the unexpected gives impetus to conceit and excessive self-confidence. These flyers think – all is simple and easy. Easy, because the professional tasks are defined by the law, but not by technology capabilities. When new tasks are posed by implementation of new technology, suddenly, problems begin to arise. Consequently, inefficient teaching creates hidden conditions, which cause unreliable performance. Hence, it is not always fair to assume a flyer's guilt.

The third 'stone' of the professional culture of the flyer is the knowledge of his own body, of the attributes of his own psychic function, to help evaluate his capabilities and limitations. Let us be truthful: we strictly judge man's behavioural blunders, yet we do not always know the laws of human behaviour. Let us view some examples.

The aerodynamic features of aircraft are such that high performance manoeuvres requires the full absence or prevention of aircraft skidding. However, with lateral acceleration the flyer's legs begin to lose coordination and slipping occurs. The muscular efforts of the legs are regulated by the spinal cord, but the errors come from the brain. Let us consider a complex flight manoeuvre: simultaneous control of aircraft weapon systems, and deliberate mental counting of seconds; safety depends on these numbers. Time perception depends on the emotional state of the flyer. Under these conditions, excitement is a physiological norm. It regularly distorts time perception thus leading to unavoidable human errors. Here the personal factor is not the cause, but the effect. If we approach this scientifically, in this case may the pilot error maybe explained by the shortcomings of the man-machine system. Therefore, the human factor (third 'stone' of the professional culture) requires objectively improved scientifically sound flying safety, especially for the determination of who is guilty.

My conclusion may appear to be subjective, since currently we still have a fairly well thought out, multi-faceted system for the support of flying safety. One facet addresses the laws of the flying service, the methods and procedures of flight training; and another, the solution technology reliability; a third entails the organisation and flight control. The fourth facet covers the problems of medical check-ups, the expertise of health status amid flying staff, and the prevention of health disorders, etc.

All this has but one goal – prevent aviation mishaps. However, since the existing system of does not fully guarantee aircrew-flying safety, we have started an 'inter-system' cooperation, as needed. It consists of a universal link between all facets of safety. Hence, the cause searching process encompasses all facets and the evaluations of the 'contributions' into the final outcome of the mishap, allow us to clearly define the prophylactic, educational, and organisational measures. Therefore, the process of the aviation mishap investigation opens that feedback, which, in essence, should help to share the total guilt with the actual culprit, who may be no longer alive.

Today's psychological climate of the aviation mishap investigation process is rather inflexible. Probably, we need to reorient the investigation technology from a compartmentalised analysis to a systemic one. This means that this flyer's actions should be judged not only on the characteristics of his control movements, but also on their motivation.

Along with these observations, special studies have revealed, that in a real life-threatening situation people do get flustered, behave irrationally, are incapable to control their own behaviour and panic. As a rule, when this occurs, the flyers exhibit their best performance. The saying "perish yourself, but save thy comrade" is true for most in the military aviation communities. The genuine flyer does not live by sentiments as "it does not concern me" or "it does not touch me". Sometimes inadequate evaluations of the flyer's fault is assumingly explained by misunderstanding of true motives for action. As a result, the flyer loses trust in himself, begins to doubt his own strengths and possibilities due to a biased evaluation of his performance. From here may arise the occasional indifference in the search for the truth. Recently, we have questioned a group of flyers in a face-to-face discussion: "Do you experience short-term spatial disorientation due to visual blurrings when exposed to +6Gz accelerations?" Of the polled flyers, 80 percent gave a negative answer. However, when the same flyers were quizzed anonymously with a questionnaire, 92 percent of them gave a positive answer: "Yes". These data suggest an unfavourable psychological climate in the aviation collectives.

Thus, the review of the flying safety issue, along with the consideration of moral criteria, suggests that this is the path to follow for improving the psycho-physiological climate in aviation. Decent, interpersonal relations with comrades in trouble, represents moral norms, which evolve in the community.

CHAPTER 4

ERGONOMICS APPLIED TO AVIATION TECHNOLOGY AND FLYING SAFETY

1. Historic Background

Ergonomics is the science that helps to understand man's work activity. It can extract the necessary information from such disciplines as medicine, physiology, psychology, pedagogics, hygiene, engineering psychology, systematic technology, and information for the purpose to develop a man-machine, environment system. The aim of ergonomic flying safety is to research the norms of the psychological and hygienic habitability parameters, to develop algorithms for the aviation specialists' activity, and to maintain maximum flying safety of the complex "aircrew aviation environment" for the preservation of man's health, work capacity, and psychological attitude to fully use aviation technology in both, the civil and the military aviation. The methodological bases of ergonomics are a systematic analysis of the professional activity of aircrews, air traffic control specialists and, for military aviation, also of the specialists of combat control and communication centres. The scientific task of ergonomics is to coordinate the psycho-physiological capabilities of man with the environmental conditions, and with the assets which he uses to prognosticate the needed efficiency and reliability achievements of the man-machine system. Engineering psychology deals with the informational man-machine interaction.

Engineering psychology, as a systemic technological branch of science, studies the aspects of man-machine interaction, which makes demands on man's mental abilities. At the same time, engineering psychology, an offshoot of psychology, investigating the psychic processes and qualities of man, formulates the corresponding demands of the technical parameters. The essential feature of engineering psychology is the study of the informational interaction of man and the technical control and steering systems.

Therefore, engineering psychology concerns man's performance using modern technology, and the processes of informational exchange between man and the technical equipment. "Its practical task," (B.F. Lomov, founder of this science in the former USSR), "consists of developing the coordination principles of the technical system's characteristics with the characteristics of the mental processes, functions, conditions and qualities of man, and to guarantee the maximum reliability and efficiency of the control and the steering systems, with a minimum expenditure of human effort." (Lomov B.F., Man and Technology, Soviet Radio Publisher, 1966, 8).

The first All Russian Conference on scientific labour organisation was held in 1921; it concerned the possible creation of a science about labour. At this conference, academician V.M. Bekhterev said that the ideal work model is not the implementation of Taylor's conveyor system, but the establishment of an activity that may allow maximum productivity with optimum health preservation, and the absence of not only excessive fatigue, but also to guarantee man's optimal health and the development of his personality.

Hence, it follows, that our scientific research about occupational activity has been based on the anthropocentric approach, i.e., from the human to the machine. The idea to adapt the machine to man was already formulated by Mendeleyev (1880) for aerial navigation. It was noted that the mechanic needs to consider not only the engines, but also the man who will control them, in order to make the aircraft "comfortable and accessible to all". The concrete application of the knowledge about man, in creating [developing] instruments and work tools, started with the study of the human anatomy and the dynamics of the work movements. Based on biomechanics and bio-anthropometry, recommendations were made for man's work stations and tools.

Later, research centred on the psychological characteristics of man. Recommendations for occupational physiology concerned not only the workstation, but also the work regime and its standardisation. The occupational hygiene standards concerned mainly the harmful environmental working conditions, negatively affecting health. Thus, occupational physiology supported the work capability of the human body, and the hygiene, protected its health.

Despite the basic knowledge of human bio-anthropometrics available in reference books,

in the 1970s the lack of proper cockpit dimensions was the leading ergonomic deficiency. In some aircraft, designed at the Special Aircraft Construction Bureau named after P.O. Sukhoi, short flyers experienced difficulties in reaching the control stick, and in the worst cases, could not reach it at all. About 20 percent of the short flyers could not reach the pedals because of the restraint straps limited adjustment range (120 to 140 mm instead of 160 mm, as required by the Russian Air Force Department of Standards). Due to the fixed body position, the short flyers, (up to 50 percent), were also unable to reach the lever of the aircraft's landing gear, as well as the emergency wheel break lever. Some flyers did adapt to these shortcomings, and, some of them, even freed themselves from the restraint straps during the landing approach, which was a violation of the flying safety instructions!

Scientific disciplines, dealing with man's occupational activity, were required to give a direct input into the development of the technological progress when the so-called human barrier emerged. It was impossible to increase the flying altitude without hermetisation of the cockpit and use of oxygen equipment, and to raise the manoeuvrability of the aircraft without anti-G suits, or to increase speed without a safe emergency escape system with an ejection seat. The problem here required predominantly a study of man's compensatory capabilities.

Originally, psychology played a rather modest role. In time, it took a front seat with the advent of the scientific technology revolution. Modern technology reduces, more and more, man's physical workload, while it increases the mental load, consequently the psychic stress increases. The analysis of emergency incidents has revealed that disorders of technological processes, in complex technological systems, continue to grow, because they are predominantly stipulated by the fact that in constructing machines, instruments, etc., insufficient consideration is given to man's psychological characteristics and to his limitations.

Despite this, I still want to underline the need for engineering psychology. It has emerged, not because of a new psychological barrier in the conditions of the creation of the new technology, but because the technological progress has led to the creation of such a complicated steering control systems, that they are not fully efficient due to their non-optimal use by man. Moreover, the human link in a man-machine system has become a braking device, which limits the success of applied technology.

The old assumption that man can do anything if he is effectively taught is no longer true. The concepts of man's adaptation to the machine, through intrusive training have been reinforced by the concepts of the man-machine interaction with the support of the idea of adapting technology to man and the consideration, not only of his capabilities, but also of his limitations (V.A. Popov, P.K. Isakov, N.D. Zavalova, V.A. Ponomarenko).

Engineering psychology and ergonomics have acquired the specificity of projecting discipline, and switch on the design process in the earliest phases of technical systems development. Its main task is not the rational inclusion of man in the control loop of the projected technical system but, based on the problems of the man-machine systems, to develop a man's activity project and determine the technical requirements necessary to create such a system (B.F. Lomov).

It appears reasonable to expound an abridged history of the evolution of aviation ergonomics. For each aviator, it is important to know that, from the inception of an idea to the finished product, military specialists, scientists, engineers, test pilots, Air Force and Air Defence Headquarters Command, they all participate. Many servicemen contributed with each detail of the aircraft and the armament. It is a pity that today, this contribution is limited by technical difficulties in its realisation, and sometime even by a genuine situation.

In 1968, for the first time in the former USSR, the State Committee on Science and Technology proposed to create a program of complex ergonomic investigations. Active participants were, among others, psychologists B.F. Lomov, D.A. Oshanin, V.M. Munipov, V.P. Zinchenko, A.N. Leontyev, academicias A.I. Berg, P.A. Kapista, B.N. Petrov, K.V. Frolov, et al. The single aim was to assure a systematic list of the psycho-physiological, the psychological, and physiological characteristics for the creation of the technology.

However, despite the government documentation, the introduction of ergonomics into the projected aviation technology was extremely difficult and painful. The aeronautical team of constructors did not lack the necessary preparation in the field of human sciences and, however strange it may be, in

the psychology of the flying activities. The difficulties were related, mainly, to the problem of flying safety. The point I am trying to make is that the tactical and technical requirements were applied to the aircraft, and the ergonomic ones to man, and this limited the technical combat capabilities of the aircraft. It all boiled down to the ideological posture: first the technology, then man will be "fitted into it". This technocratic thinking crushed a human approach: "the aircraft is not a recovery place, the military man is a soldier, and he must accept all the burdens for which he is paid". Yet, finally, ergonomic services were established in scientific institutes with branches in the civil aviation, in the military aviation, and in the Ministry of the aircraft industry. The major contributors for the establishment of experimental ergonomics in aviation are General Constructors, R.A. Belyakov, M.P. Simonov, M.N. Tishchenko, S.V. Mikheyev, G.V. Novozhilov, O.K. Antonov; engineers, S.S. Darevsky, R.V. Sakach, A.A. Polsky, P.Ya. Shlayen, Yu.P. Dobrolensky, M.M. Yurovitsky, S.L. Belgorodsky, Yu.A. Yanyshev, M. Yakubovich, G. Sinevich, V.S. Linyakov, O.K. Rogozin; physicians, V.A. Popov, G.M. Zarakovsky, psychologists K.K. Platonov, Yu.A. Petrov, N.D. Zavalova, V.A. Bodrov, and V. Lapa.

The Institute of Aerospace Medicine was assigned the leading role. Even among the physicians, there were differing opinions on the necessity of founding an ergonomic service. This will be discussed later in a special chapter. The problems of medical support, restraining, transition and acquisition of a new technology, development of safety measures, rescue equipment, investigations of the negative effects of flight factors, corroboration of medical control, and methodology to ensure flying safety were solved mainly at the time of equipment delivery to the military units, and after positive and negative operational experiences. The safety measures were often based only on physiology without consideration to aircrew's combat activity.

The investigation methodology was based on a concept of 'functionalism', i.e.; each individual is concerned with his 'own' flight factor without full consideration of the whole system "flyer – aircraft – environment" function. Starting from the 1970s, V.A. Popov, N.D. Zavalova, and G.M. Zarakovsky were asked to found 're-orientation' which started aviation psychologist to join the military scientific development of aviation technology and ground control communication. The efforts of many specialists unified the approach principles. As a result the level of advanced research increased substantially. The Air Force Scientific Research Institutions were supplied with computer technology, which allowed them to accelerate from 4 to 6 times the implementation of the medico-psychological recommendations into safety measures, rescue, and life support systems. More than 70 percent of the instrumentation developed for the third-generation aircraft was submitted to engineering and psychological expertise. In the combat flight training centres, mathematical models were used for the estimation of psycho-physiological criteria of man's training and psychic stress during the transitional phase.

The main task of the initial stage of ergonomic research consisted in establishing a new scientific orientation to meet the requirements of the future developments of aviation and armament. All this led to the decision, in 1975, by the Military Industrial Committee, "to improve the ergonomic characteristics of aviation technology".

An experimental base was established with a powerful computer complex, and the following documents were prepared: Manual on Ergonomic Specifications, textbooks and a government standard (B.15203-79), a mandatory prerequisite "to develop tactical and technical aviation technology as the requirements of ergonomics and technical aesthetics". Ergonomic branches were established in all military scientific research institutions. The Armed Forces General Staff ordered all its departments to consolidate research and development publications ("Deduction", "Vanguard", and others). In the Air Force, owed to the efforts of generals O.K. Rogozin, S.A. Mikoyan, Ye.V. Tyorkin, N.I. Grigoryev; Colonels V.V. Somik, K.Yu. Koroza; Deputies of the Air Force Headquarter Commanders A.N. Yefimov, I.I. Pstygo; and V.V. Reshetnikov, a military scientific institute of aviation technology and ergonomics was founded.

The military scientific service is a set of measures aimed at the development, the construction, and the implementation of the ideology of the military, technical policy, of the engineering, the medico-psychological and the ergonomic requirements of all the elements of the work environment which concern any military specialist. The methodology of the military scientific service became a systemic approach aimed at the creation of work conditions assuring the enhancement of general educational, cultural and moral levels of military specialists, the

conservation of professional health, and of high occupational capabilities allowing to achieve high reliability and efficiency of all man-machine systems. The flyers should also be familiar with the names of the physicians and psychologists, who contributed to the development of the ergonomic discipline in aviation and, in particular, in the military scientific services. They are: K.K. Platonov, A.G. Shishov, V.A. Popov, P.K. Isakov, Ye.M. Yuganov, N.D. Zavalova, S.A. Gozulov, V.A. Bodrov, E.V. Lapayev, G.M. Zarakovsky, G.P. Stupakov, L.G. Golovkin, V.V. Lapa, A.M. Peshkov, B.L. Gorelov, O.T. Baluyev, L.S. Khachaturyants, and many others. Special contributions were made by the specialists of the Air Force Engineering Academy named after N.Ye Zhukovsky, under the leadership of Yu.P. Dobrolensky, A.A. Krasovsky, and the participation of V.A. Protopopov, and test pilots from the government Scientific Research Testing Institute named after V.P. Chkalov, and under the command of S.A. Mikoyan, G.A. Butenko, A.A. Manucharov, A.A. Polsky, and S.D. Dedukh. The introduction of ergonomics into the research and the development of aviation technology has greatly benefited the flyer, as remarked by author A. Markusha.

The technical project, from the inception of the idea to the test flights, relied on the knowledge of man's operational capabilities and limitations, on the knowledge of his professional readiness of the technical methods of training, and other factors related to man. In analysing incidents or poor efficiency, the emphasis focused on the insufficient use, by the aircraft builders, of the experimental data on the psycho-physiological capabilities and limitations of man.

In 1974, a scientific-methodological, and organisational cornerstone was laid for ergonomics – a new aviation technology. It is sufficient to note that the carried-out investigations, in the scientific research department of the Air Force Headquarters Command, under the command of the Air Force Engineering Academy named after N.Ye. Zhukovsky, permitted in part not only the improvement of some of the experimental equipment, but also of data on the engineering and psychological factors during the projection and the testing of the informational presentation of flight parameters with consideration to human factors. (Manual on Engineering-Psychological Models, 1974, as well as Methodology for the Testing of the Instrumental Information of Human Factors, G.M. Zarakovsky, A.A. Medenkov, B.L. Gorelov, S.L. Rysakova-Rameshkan).

A new status of the documentation, as a result of the interaction between the Customer's Services and the industrial organisations, contractors and subcontractors in the form of "regulations of military-scientific services", opened new avenues for a productive cooperation, including a joint experimental effort to improve research procedures. Based on the decision of the Air Force Headquarters Command, parts of the information presentation systems, designated for military aircraft, should pass, before their production, an engineering and a psychological evaluation test (N.I. Grigoryev); Institute of Aviation and Space Medicine, scientific and technical support of General Aircraft Constructors, R.A. Belyakov and M.P. Simonov, Special Aircraft Design Bureau named after A. Mikoyan, and Special Aircraft Design Bureau named after P.O. Sukhoy. Thus, the Air Force scientific and technical complex was created for the engineering, the psychological and the ergonomic investigations, and testing of mock-ups and experimental equipment parts.

These investigations guaranteed the on-ground and in-flight tests of the human factors, as well as the evaluation of the basic concepts for the construction of new cockpits, controls and weapon systems, and the evaluation of equipment samples. We also considered the rationale of the testing methodology of the human factors, and the selection of the criteria for the estimation of the aviation equipment for government and troop testing. As a result of this research, a scientific prognosis of the efficiency of the "flyer – armament – aircraft" system was formulated. Thus, the 'spiritual demands' of the new scientifically organised, technically produced data, were applied to aircraft construction meeting ergonomic, engineering, and psychological requirements (P.K Isakov and V.A Ponomarenko).

The experimental test beds for the new aircraft were organically included in the overall system of the aircraft design. In other words, the ergonomic research was incorporated into the planning process. The test of the investigations consisted in finding the most rational, albeit compromised, best possible decisions for the 'man-machine' system. Such cooperation by the specialists of the Air Force Headquarter Command Scientific Research Department, and the Special Aircraft Design Bureau of the Aircraft Manufacturing Industry

Ministry provided the three most important functions, the use of which allowed the General Constructor to systematically resolve the most complicated scientific, technical, and organisational problems during the construction of the aircraft and the later improvements.

First function: Work out a number of technical problems related to the control and the weapon systems, aerodynamic characteristics, etc., by using semi-natural models.

Second function: Work out control, and revision of the requirements of the subcontractors, installing of the equipment, and of the psychological capabilities and limitations of man based on the semi-natural models.

Third function: Develop a systematic ergonomic research which will allow to prognosticate the 'flyer-aircraft' system efficiency, safety in flight, identification of the most likely causes to lower the efficient operation of the aircraft, the formulation of purposeful programs to check the effect of these causes in actual flight conditions.

To support the usefulness of these functions, we shall use some MiG-29 examples. Using ergonomic test equipment, we checked the new instrumentation on a CRT-display, and the oral communication and signalisation of special regimes. On the basis of the received data, radical changes were made before approval of on-board installation. Significant, necessary adjustments were done to the autopilot systems of the KAP-2, KAP-3, AP-155, and SAU-23, the command flight director indicators, the air speed and the altitude instruments, and feed by pilot inlet tube and engine control, including the commercial aircraft.

The Special Aircraft Design Bureau applied the principles of centralised warning systems, the laws of direct aiming steering, and the requirements of vertical scales for the new generation instrumentation, etc.

As a result, we may conclude, that the Special Aircraft Design Bureau disposes of equipment better 'fitted' for the needs of the flyer; can reduce the number of critical reproofs at plants and for government tests which, for the human factor consideration, was most desirable. We were successful in concretely adding the ergonomic 'man-machine' system to the government testing. This concerned specifically the general methodology. Thanks to the test pilots, new conceptual approaches were implemented to flight-testing. In part, the ergonomic testing of the aviation technology was carried out also for the prognostication of its potential implementation in operational units. This prognostication is a systematic representation of future uses of the aircraft, including proposals for the training and the education of flight engineering personnel, support for work performance and health of aircrews, the manufacturing of new protective measures against environmental danger and operational, technical, teaching tools (V.Ye. Menitsky, N.N. Adamovich, I.P. Volk, V.V. Migunov, V.Ye. Ovcharov, and V.I. Tsuvarev, et al.).

Since experimental technology links industry to the Armed Forces, it is obvious that ergonomic specialists have accumulated knowledge of aviation technology experimentation for the benefit of the Armed Forces. They have made medical recommendations for health control based on the new risk factors, planned psycho-physiological training, as well as the development of trainers and new rehabilitation approaches, and premises for acceleration reliability, etc. In other words, the ergonomic aviation technology testing became a catalyst of advanced scientific ideas for aviation personnel safety (P.S. Kutakhov).

2. Ergonomics and Flying Safety

With regard to the human factor during aircrew performance tests on new technology, the ergonomic scientists tried to 'include' all potential harmful factors that could threaten aircrew safety. For this purpose, they studied a full range of non-standard flight situations, and all kind of negative hygienic conditions, which can decrease performance. They also determined the degree of technical protection measures and made recommendations to raise aircrew reliability. This approach sometime annoyed the constructors since, they opined that it stemmed from criticism and was unproductive. But the aircraft is built first and then put into service. Thus, the ergonomic research is a substantial addition to the design, since the contractors start from the simulation of the projected performance. All the negative aspects disclosed by ergonomics are taken into account buy the constructor and by the flight instructors. Therefore, the shortcomings cited below should not be considered criticism. The flyer should be aware of those objective difficulties, which he might encounter during his flying career. I believe that

this material will be of interest to the future specialists in the field of flying safety, to analyse aircrew errors, to flight instructors, and aviation physicians and psychologists. After reading this chapter, the reader may wonder how come this technology overlooks many ergonomic deficiencies. But this is a subject for another book. Usually, in the daily flying practice, many defects are compensated by the flying abilities, by the health, and at times ... by the flyer's life. But in the latter case, the pilot takes the blame. So that everyone may be aware of the overall responsibilities, I shall present the facts to help establish the truth. This became clear to me in the early 1960s and, in time, even clearer. In the 1970s, summarising the research of cause and effect of the human factor 'blame', it was I who formulated the then new socio-technical premise of the necessity of ergonomics research and development, at this early stage of aerospace technology.

At first, there appeared to be an incompatibility between the aviation equipment complexity and the psycho-physiological limitations of the human factor during both, the design and the training phases. This carefully hidden incompatibility does explain a set of non-rational, technical decisions taken during the construction of the control systems and the aircrew work areas, which later acquired the quality I call "built-in incident promoting and error facilitating". The example of, such poor unsuccessful decisions, will be described in paragraph four of this chapter. The second prerequisite for the ergonomic investigations was the increased aggressiveness of the environmental factors and the habitat. This includes the effect of impact acceleration, of electromagnetic and laser exposure, of toxicological effects of oil and hydraulic fluids, of thermo-oxydative products of some fuels, etc. All this presented real risk factors of decreased flying safety and health deterioration.

The experience of the operational medical control, and of the crew performance flying the fighter-aircraft of the 3rd and 4th generation, has evidenced that the working place of the flyer is dictated by technical specifications, scientific research, and corresponds mainly to the psycho-physiological crew capabilities. This is confirmed also by objective proof, mainly by a low rate of occupational morbidity (3 percent), less than 1 percent incidence due to flyer's work incapacitation and health disorders, less than 1 percent due to trauma, no grounding due to disabilities caused by direct exposure of negative flight factors. However, a study of this problem, using experimental investigations based on flying safety, and the flyer's performance reliability, evidenced a series of oversights. In these experiments, we introduced ergonomic aberrations directly affecting the reliability and efficiency of the human factor. They included, insufficient out-of-cabin view, uneven cockpit illumination, irrational layout of control panel and instruments, information overload, poorly organised time-shared activities for steering and spatial orientation, insufficient reliability of automated control systems and on-board computers, moreover, poor intra-cockpit micro-climate, survival garments, reliability of ground navigational systems for instrument-landing, incomplete conformity of flight trainers and other technical training devices to match flight mission complexities, (meteorological minimum, extremely low flight altitudes, aerial combat manoeuvres. Yu.A. Petrov, V.V. Lapa, V.V. Polyakov, P.S. Turzin, Yu.V. Kamenshchikov, et al.)

These shortcomings caused a prolonged psychic stress in the flyers. The crews observed this in the following negative situations:

- marked fatigue and decreased psycho-physiological reserves in one-third of the flying staff, up to 7-8 months after scheduled vacation;
- delayed post-flight recovery of psycho-physiological functions (attention span, memory, reaction time, operative reasoning, coordination, and decision-making) by 6 to 8 hours as compared with second-generation aircraft (N.I. Frolov, P.I. Shalimov);
- decreased work capability during exposure to noise, and vibration at the 4th hour of flying activity, and decreased tolerance to both.

In establishing the Course for Combat Readiness, there was insufficient consideration for the actual equipment in the algorithms of navigational equipment, and weapon control systems performance also lacked true technical specifications. The automation of the aircraft control and weapon systems did not match the work conditions at the workplace of the aircrews. It needs to be noted that a reliable use of the new technology was complicated by a substantial lagging of technical safety measures against occupational dangers (V.V. Kustov, V.I. Belkin).

The experience of the medico-physiological support of flights on the fourth-generation aircraft,

and the results of their ergonomic application allowed **us** to establish remarkable sequelae of the ergonomic shortcomings.

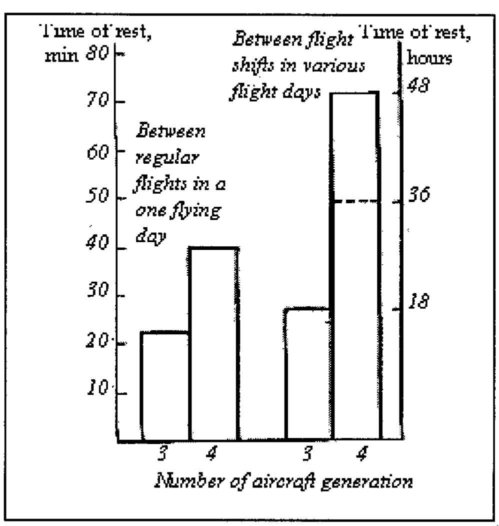
In the last five years, a clear trend of an increased medical disqualification has been observed in the 35-40 year old first-class pilots. In 1980, 16 percent, in 1985, 32 percent, and by 1992 there was a real peak of medical disqualification incidences – 41 percent. In the process of the fourth-generation, fighter-aircraft operations, we saw an increasing effect of constantly present flight factors, such as aerial combat manoeuvring accelerations, impact G forces, decreased locomotor activity against a background of increased psychic stress, time deficit for decision-making and of rpm, as well as spatial disorientation. It suffices to mention that during an aerial combat manoeuvre exposure from 5 to 7 Gs was 40 to 60 seconds, with a maximum of 8 to 9 Gs, and an onset rate of 4-6 Gs/second. The arterial pressure reached 240/120 mm Hg, and the heart rate increased to 200 beats per minute.

During the landing on a navy carrier deck, impact acceleration in the flyers head, reaches 15 to 20 Gs lasting 0.5 to 0.7 seconds, and may cause a brain micro-concussion. It should also be mentioned that during high manoeuvring flights of Gz ranging from 0.3 to 10 G., which, together with increased angular rotations (150 degrees/second) would cause spatial disorientation – see below.

Let us consider now the actual ergonomic insufficiencies, which were found in the process of man's interaction with technology, during actual combat training tasks. I am, by no means, trying to shift the responsibility for poorly trained aircrews to the aviation technology constructors. My main intention is to demonstrate the existence of hidden, situations threatening flying safety. Figures 1 and 2 support the assumption that the new technology increases the work complexity which, in-turn, raises the number of errors. Figure 1 shows, in part, that the number of errors depends upon the complexity of the instruments. It should be noted that a predominant number of flying incidents has occurred during ground target acquisition and strike missions (Figure 2).

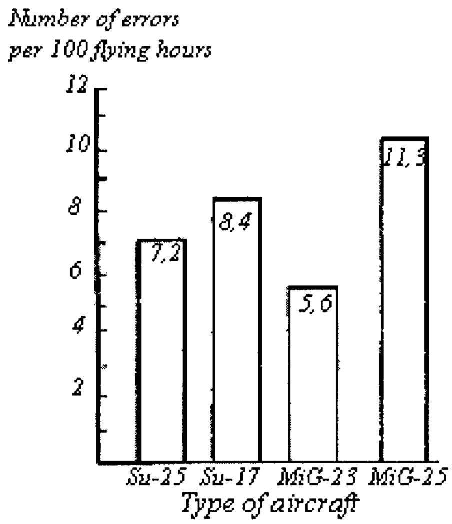
I would like to emphasise that, despite the high reliability of the control functioning and a display systems presentation, man's adaptation is still low. The result of this discrepancy is an objectively lowered reliability of aircrew performance. A professional analysis of the steering technology on the fourth-generation aircraft allowed us to objectively determine the dependence of the flyer's errors on insufficient or distorted information presentation, which may affect flying safety. Quantitative data, affirming this, are shown in Table 9 on page 65.

The transfer from the electromechanical flight instrument panel to the electronic flight display systems does not necessarily facilitate flying tasks. The point is that, now the smaller display panel presents a much greater volume of information, than on the electromechanical panel.



Two left bars are related to the left axis of ordinate, designating demanded work capability restoration time and minutes between two regular flights in a one-flight day.

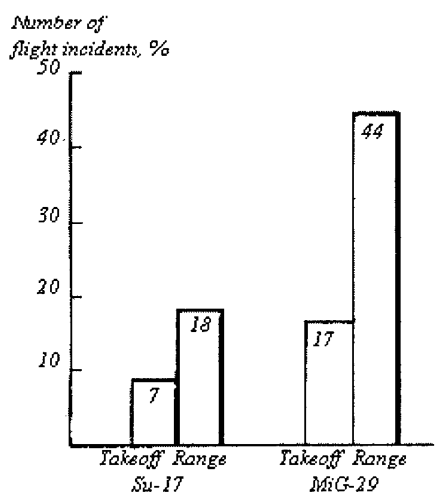
Two right bars are related to the right axis of the ordinate, designating demanded work capability and restoration time in hours between two various flight days.



Ordinate - number of errors/as hours.

Abscissa - type of investigated aircraft, Su-25, Su-17, MiG-23, MiG-25

Figure 1. Dependence of flying on complexity of intra-cockpit equipment.



Axis of ordinate - number of flight incidents in percent.
Axis of abscissa - type of flying mission and type of piloted aircraft Su-17 and MiG-29.

Left columns - takeoff of aircraft.
Right columns - high-precision ground target striking - range.

Figure 2. Dependence of aviation incidents on ergonomic indices of the man-machine interface system.

Table 9. Aircraft steering errors during ground target acquisition related to deficiencies in the information display system.

Type of errors	Percent distribution of all types of errors
Trespassing values of flight parameters on combat bearing flight path (speed, roll angle, angle of attack trajectory)	22
Trespassing value of acceleration during recovery from diving	16
Recovery from diving at an altitude lower than the safe limit	48
Further deviations (non-maintenance of combat formation and order, time of ground attack, etc.)	14

As an example of the depth and the professionalism of ergonomic research performed to assist the constructor, I will analyse the results of the flyer's performance while using the electronic display. The main difference of encoding and presenting flight information displayed on the equipment of the type SEI-31 – [Systems Yedinoi Indikatsii – System for Unified Indication] in the form of digital calculators, vertical scales, indices of flight parameter changes, from the traditional, needle in round dials requires special mental expertise by the aircrew. This concerns specially, the conditions of the rapid changes in out-of-cabin luminance, due to the poorer illumination characteristics of the SEI-31, when a pilot needs to transfer from steering the aircraft by the electronic head-up display to steering it with the more familiar electromechanical flight instrument panel, and vice versa. Thus, the presentation of diversified, encoded flight information demands sophisticated ingenuity from the flyers.

According to questionnaires, 23 percent of the pilots experienced substantial difficulties during the changeover from collimator (head-up) indicator to head-down instrument panels, and vice versa. Furthermore, according to subjective estimations, the time of eye movements, from one visual field to another was 1.5 to 2 seconds. In the process of ground target acquisition, under complicated meteorological conditions, the flyers used flight parameters for their spatial attitude. The introduction of the HUD, indicator, for the pitch scale during automatic target tracking by radar, allowed the flyers to optimise attention distribution (the relative time of the flyer's distraction from the HUD to the head-down instruments was three times less); the probability of flight mission ground target attack dropped from .08 seconds down to .02 seconds. The quality of target acquisition and precision strike was markedly improved, 1.3 times (with a corresponding drop of misses).

Our data have indicated that disregard for the flyer's psychic capabilities, in designing the information display, reduced the efficiency of the ground target attack. This evidenced some problems with the target approach manoeuvre prognostication due to the duration of more than 1.5 seconds to change from an HUD indicator to the automated regime, (information blackout of 1.5 seconds), which led to aerial attack abortion in 6 percent of cases, and an increase in neuro-emotional stress. On the other hand, the disproportionate movements of the stick during target strobing, along with a discrete strobe movement (due to a lower frequency, 5Hz, of information delivery to the unified indication system), causes an abortion of aerial attack in 10 percent of the cases (S.A. Ayvazyan).

One of the characteristic ergonomic deficiencies, in designing the informational field, is the insufficient continuity of different controls and of the information presentation. Restructuring the motor sensory pattern performance, and changing the spatial orientation during the transition from automatic target acquisition (HUD and radar sight) to aiming by a non-synchronous method, has shown a significant deterioration of target acquisition and hit characteristics with 1.5 times increase of the total time span for target acquisition and re-aiming.

In an ergonomic experiment, before the flight tests, we uncovered a series of construction deficiencies decreasing the flyer's efficiency during aerial

target intercept. For example, a very small effort in moving the stick, (der Knüppel), caused large deviation of the aiming mark, and an increase of the strobing time of the target. The poor location of the weapon control switches required additional visual attention, and the time expenditures for finger movements sometime caused errors.

These data were used to improve all systems under consideration and as a source of information for flying safety services. However, when errors became a liability, the responsibility was shifted to others...The analysis of decreased aircrew reliability, rarely considered the psycho-emotional reactions to flight factors, which are not always corrected by the new equipment and the on-board automation.

Figures 3, and 4 show the dependency of the emotional stress and the performance characteristics on work conditions during flights at a meteorological minimum, and at an extremely low altitude. The presented data allow us to assume that, regardless of the degree of automation, actual life threat constantly increases the psychic stress of the flyer. In this connection, I shall mention an additional source of flying safety reduction. It concerns automation which, by itself, raises the risk limits because it places man in a situation where, without automation, he is incapable to carry out the flight mission. Therefore, the low reliability of the automated control systems is a constant psychic stressor. For example, in frontline aviation, the fighters lack the warning signals to alert them about a computer failure of the automated control systems, and the back-up channel. The ability of the fighter pilot to prevent breakdowns is very limited (Table 10).

Questionnaires filled by the pilots, while learning about factors which increase the emotional stress, revealed, that 80 percent attributed the cause to the absence of back-up channels in the automated control system. Furthermore, the complexity of the navigational equipment, and the excessive workload, aggravate the psychic stress of the navigator and the weapon guidance operators.

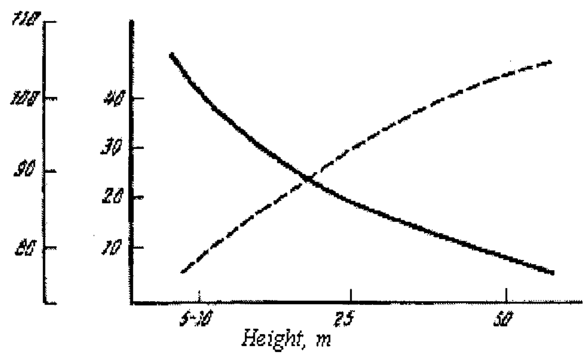
As to the projection of the workstations, special reasons for decreased safety levels came to light – the so-called moral ageing of the equipment during the design stage. For example, the giant airlift cargo plane AN-125, built already 10 years ago, is a result of the information received from aircrews in the late 1960s and early 1970s. It is equipped with electromechanical instruments only, no forewarning means of navigational parameters, and the navigator must gather the information on aircraft attitude from 5 to 10 instruments. This demands, of the navigator, long work hours and a heavy workload (up to 5 to 7 tasks every 15 seconds), and a mandatory check of three or more logic parameters.

The new aviation technology requires that the navigators use a constantly growing number of navigational communication systems located in the most unexpected area of the cockpit. At the navigator's workstation of the strategic bomber Tu-160, the total number of acronyms exceeds far beyond 500, which represents an independent artificial language.

To the present, we have widely used letters of the Russian, the English, the Greek, and the Roman alphabets. The navigational maps are prepared without consideration to flight specificity's of the modern conditions, and disregard of currently designed navigational complexes. Poor quality of aero-navigational maps, and the lack of automation lead to a paradox – the use of modern navigational complexes extends the time of aircrew pre-flight briefing, (namely, for 1 flying hour, it is necessary to waste 3 hours navigational briefing).

These examples show the contractors did receive from the Air Force specialists, substantial ergonomic recommendations which, though experimentally validated, were not fully implemented into mass production. Table 11 (on page 68) illustrates the cost to the military for disregarding the advice of scientists and test pilots. These data indicate that flying safety is not always directly related to efficiency, and genuine safety should not conflict with the achievement of optimal results, under the most complex flight and combat conditions.

This is, so to say, a theoretical premise, but in practice it has been proven that unreliable aircrew performance and decreased performance are precursors of flying incidents, because of poor flight training, low quality flight management and personal discipline, as well as, failures of the equipment. Actually, there is a whole series of human errors due to enhanced technology, excessive psychic and physical workloads, and psycho-physiological limitations. To neutralise the factors threatening flying safety, it is necessary to implement an ergonomic control at all the stages of aviation technology.



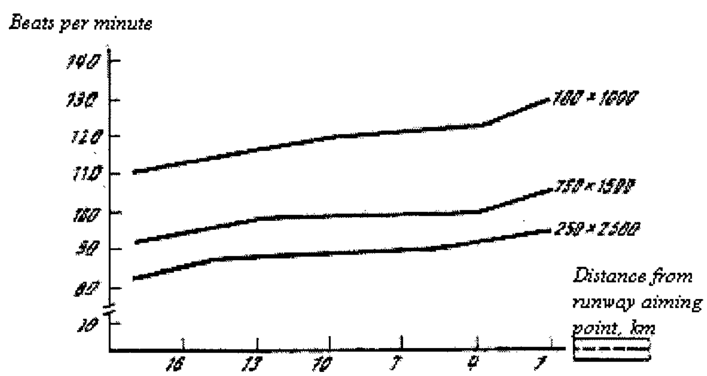
Axis of abscissa - height in meters.

Axis of ordinate - first line - cardiac frequency in beats per minute; second line - the reserves of attention for fulfilment of ground target acquisition.

The solid line - dynamics of cardiac rate of flyer.

The dotted line - dynamics of attentional reserves of flyer.

Figure 3. Emotional stress and attention reserves of the flyer in a rotary aircraft in dependence of altitude.



The graphic curves characterise the visibility conditions during flyer's visual contact with runway, where first figure signs - lower edge of ceiling and the second figure - the visibility on slanted horizontal distance from runway aiming point.

Axis of abscissa - distance from runway aiming point in kilometres.

Figure 4. Dynamics of flyers cardiac rate during landing approach in automated control regime in instrumental flight rule conditions of various visibility degrees.

Table 10

Type of failure	Probability of detection	Probability of recognition	Time of detection	Probability of successful landing
Failure of computer in lateral channel of control	0.85	0.54	16.8	0.57
Failure of computer in longitudinal control channel	0.69	0.49	0.28	0.62

Table 11. Results of human factor contempt and neglect admitted by fourth-generation aviation technology.

NN ordinal number	Revealed shortcomings	Stages of technological cycle		Elimination	Remote sequelae of neglected recommendations on aircraft readjustment and perfection, including errors in operational units by flyers
		Modelling	State tests of experimental sample		
1	Irrational layout and arrangement of aircraft armament control system in cabin	+	+	–	Break-down of ground target attack due to protracted time of armament control system preparation in typical regimens of combat application
2	Prolonged (up to 5 s) transfer from radar and boresight 'viewing' regime to that of 'automatic accomplishment'	+	+	–	Break-downs of ground target attack due to impediment of target approaching manoeuvre prognostication
3	High sensibility of stick, impeding target strobing	+	+	–	Break-down of target acquisition, augmentation of target acquisition time
4	The throttles in position "Afterburner chamber ignition" shield the switches of "photocamera shooting gun" and "fuel shutting faucet of left engine"	+	–	–	Engine shutting off due to confusion of toggles and switches
5	The lack on head-up electronic display [SEI] of the target approaching velocity indicator	+	+	+	Break-down of target acquisition due to impediment of time approaching calculation

3. Psychological Requirements of the Flyer's Workstation

Psycho-physiology is a branch of aviation medicine, an offshoot of the medical science, the first to demonstrate that flight conditions do not provide man with an adequate environment, and a guarantee of work safety. Consequently, the primary responsibility of aviation medicine is to study the psychological and biologic adaptation of man's organism to the unfamiliar environmental conditions; and for this purpose to simulate these environmental conditions.

Generally speaking, this scientific approach could be regarded as a normalisation of the work conditions, warranting man's life support activity and performance. In as much as the organism cannot exist without life support systems, aviation medicine had to solve a dual problem: satisfy the

technical progress requirements and to preserve man's health and performance in the extraterrestrial environment. The flyer's habitat consists in his workstation, the cockpit which is a sealed cabin containing control, flight display systems, the ejection seat, and a special microclimate.

The flyer's workstation is mainly viewed for the hygienic requirements to maintain health and the basic physiological norms supporting normal body functions. Despite the significant improvement of the flyer's workstation design, little by little, important omissions came to light. Why did a gross incompatibility of separate elements, as of the whole workstation, emerge for the psycho-physiological capabilities of man?

Technical progress in aviation traditionally legalises the 'machineocentric' approach to the analysis of the 'pilot-aircraft' system, which may be defined as the approach "from the machine to the man". With such an approach, efficiency and reliability, first of all, were related to training and education of man, i.e., by 'fitting' man to the built machine. Thus, one thought the machine can do all, but because of man's limitations, it cannot achieve its full potential. However, the task of survival and health preservation of the flyer is not the same as increasing the safety of the pilot-aircraft system. The practice of aviation accident investigation, as to the causing conditions, abounds with examples of healthy and work-able flyers who erred. And the aircrew is also blame for errors. But, if we thoroughly consider this, then the question arises why, for 10 to 15 years, the share of the flyer's errors, and of the related aviation incidents, is held in the forefront?

Let us analyse the main characteristics of the flyer's workstation based on the maintenance of the performance reliability. As we mentioned earlier, the workstation represents the prime space, which contains the flyer. It is a common knowledge that one of the main deficiencies of a single seat cockpit, of the third and fourth generation fighter-aircraft, is its small size. The basic dimension of the cabin is far from the norm established by the overall technical requirements, which seriously interferes with an error-free performance. I will demonstrate this with concrete examples (Table 12).

The data shown on Table 12 may be differently evaluated. Traditionally speaking, we should relate the insufficiencies to the health or to the performance of the flyer. However, if we consider vested performance guarantee on reliability of the 'human-machine' system the picture changes. Indeed, what does it mean for the flyer that the width of the cabin is not according to the 'norm'? It means that in the case of an emergency the pilot's elbows may be injured during ejection.

The second problem of the flyer's workstation concerns the instruments, which he uses in the absence of visual control during time-shared activity. Table 13 reports on be needs of one third-generation fighter aircraft.

Meanwhile, officials of the aviation safety services, analysing the cause-effect relationship of aviation incidents ascribed to man error, continually asserted "that the most frequent man-error cause is a rash decision and lack of supervision for performed procedures". But, how could we agree with such statement, if aviation constructors violated government standards in building the cockpit? I would like to emphasise, once more, than many of the flyer's errors are related to the disregard, by the aviation constructors, of man's characteristics, particularly his body proportions, mental reactions, and stereotype actions.

Often, the flyer's errors are prompted by insufficient out-of-cabin view. Table 14 shows the discrepancies between the requirements of the Air Force Department of Standards of the actual out-of-cabin view.

The limitation of out-of-cabin view significantly reduces the efficiency of some aircraft combat manoeuvres, and generates aviation incidents independently of man's work capability. For example, during takeoff and climbing at an angle of 15 to 20 degrees, the out-of-cabins view is practically nil. During a landing approach, above the point of aerodynamic flare-out, the runways is beyond the flyer's visibility range, or in the 'blind-zone'. During combat missions, at low, and extremely low altitudes, the average time reserve from the moment of target recognition to its disappearance into the 'blind zone' is very short.

As we expounded earlier, the aim of aerospace medicine is to assure the habitat's physiological and hygienic parameters. Another very important aspect is the adaptation of the aviation technology to the psycho-physiological capabilities of man. This brings us to the study of a different approach – the "man-machine environment" system.

Table 12. Anthropometric discrepancies between required and actual dimensions of some fighter-aircraft cabins.

NN Ordinal Number	Measured parameter	Demanded or required dimension by state standard	Actual dimensions in aircraft cabins of 1 to 3 types		
			1	2	3
1	Width of cabin in flyer's elbows areas (mm)	850	670	735	780
2	Height from seat cup plane in mid-position regulation range up to visual axis or line of aiming (mm)	770	775	787	780
3	Range of seat regulation height (mm)	170	100	100	100
4	Probability of misalignment of eyes at aiming line due to insufficient adjustment of seat height	–	8 percent	12 percent	12 percent

Table 13. Some discrepancies in required (standardised) and actual geometric allocations of flyer's controls*.

Controls	Demanded by state standard geometric location of controls	Real geometric location of the same controls in the cabin
Lever for emergency landing gear down setting or deployment	Left panel	Right panel
Toggle for engine fuel shutting off faucet	Central part of panel	Left vertical (port) board
Toggle for emergency engine initiation	Upper edge of vertical panel	Left vertical panel
Handle of lever for braking chute release	Ahead of throttle	At the back of throttle

*Footnote: In 1970-1980s, due to confusion of control organs on the third-generation fighter aircraft cockpit there were constant 60 to 70 percent flight incidents.

Table 14. Discrepancies requested Air Force requirement specifications and actual out-of-cabin view for some third-generation fighter aircraft.

The direction of eye fixation	Vertical angle of out-of-cabin view (°)			
	Actual angle of out-of-cabin view in four types of third generation fighter-aircraft, demanded by air force departmental standards for all fighter-aircraft's cabins accomplished by aircraft producers			
	1	2	3	4
Forward-down	15	7	10	9
Down	35	17	22	12
Blind or no-view in forward Direction	3	7	5	8

It concerns an anthropocentric approach, i.e., an approach "from man to the machine" (Academician B.F. Lomov).

Proceeding from the anthropocentric approach, under environment or habitat one should understand the complex of physical and psychological factors influencing the flyer in the process of his interaction with technology and the changes in the 'flyer-aircraft-environment' system. The following relates to these factors:

- Hygienic: assuring the conformity of the equipment construction and of the habitat conditions to sanitary and hygienic norms established by the legislation.
- Physiological and biomechanical: characterising the conformity of work tool construction to the anatomo-physiological features of the human body.
- Physiologic: indicating harmony of the reinforced and learned skill capabilities of perception, memory, and reasoning.
- Aesthetic: promoting the establishment of an emotional background conducive to active work performance.

However, the main point is not just in simply adding-up all the aforementioned factors, but in coordinating them into one unified system. Therefore, thanks to the use of the activity principal method we have the possibility of a more comprehensive evaluation of the flyer's workstation. This is illustrated by the example below.

To assure the survivability and performance of the flyer, pressure suits of the "Sokol (Falcon)" type were designed and produced. The physiological and hygienic investigations, performed by the manufacturer of pressure suits under hypobaric conditions, have demonstrated enhanced protective capabilities. However, engineering and psychological expertise of the flyer's workstation, and of his activity with donned pressure suits, revealed that 10 percent of the tasks could not be performed during flight missions; 40 percent of the working tasks, using the weapon control panel were extremely risky and attended by aircraft steering inability and exceeding operational limitations. These experiments have also shown, that viewing of more than 12 panels, including the oxygen equipment indication system, was practically impossible. Thus, it became clear, that the pressure suit had been developed without consideration to the flyer's workstation, and also without consideration to the limitations of the special protective equipment. This resulted in the necessity of substantial improvements of both, the pressure suit and the cockpit. Therefore, labour psychophysiology and hygiene, as the subject-matter of their own investigation, should not choose the workstation, the individual qualities of the psychic activity or the analyser's functions, the individual environmental factors, but all to-be-studied phenomena as a whole system.

One of the main components is the ejection seat. This seat is not only a means of escape, but also the working place of the flyer. In accordance with its two-fold designation we should estimate its efficiency. First of all, the ejection seat should warrant the comfort of the flyer, accessibility to controls, adjusting of the seatback, etc. Incompatibility with these requirements leads to a decrement of the flyer's performance. Hence, it follows that the requirements of the workstation should be based, not only on natural qualities of a given element, but also on the system's qualities.

The principal of the system's analysis is applicable also to the calculated estimations of such a category as reliability. As is well known, under the term reliability we understand it to be the probability of flawless work, for a given time interval and at given conditions. Let us take, for example, a signal lamp in an emergency situation system. Its natural qualities are: running for a number of hours, to correspond to the threshold characteristics of the analysers and the mental function of the code transformation into an image of the situation. By not complying with these principles, the light does burn reliably, but the human eye cannot see it in the bright sun. As a result, man's performance is unreliable. Even these simple examples show the need for a systemic approach to establish scientifically substantiated requirements for the flyer's workstation.

Scientifically validated requirements of flight display systems would be impossible without the study of the reception process, the evaluation and storage of information by man, i.e., without studying the informational interaction of man and machine. Such interaction implies mental processes of conceptual model formulation and operational flight images, and their correlation with the informational models. This means that when man controls a system such as an aircraft, he first transforms the visible picture of the external world, and that represented on the instrument panel into

his own model. Secondly, man at the controls not only reflects the visible reality, but, mentally, he also formulates the future situation, i.e., the target representing the result of the action.

The main specificity of the flyer's intellectual performance consists in that he may work not only with a visible object, but also with the one presented by conditioned codes on the different instruments and aiming devices.

The different information modes and codes of identical parameters of the aircraft motion, during different flight regimes, present special problems. All this requires a special flexibility of the operational images along with the automated skills. Thereby, I wish to emphasise that the scientifically based prerequisites, for the flight display systems, are impossible without a thorough psychological analysis of the flyer's activity. Psychological and hygienic investigations alone are not sufficiently capable to warrant the safety of the 'pilot-aircraft-environment' system.

The question may arise: is the guarantee of normal vital activity of the flyer the main prerequisite of man's safety in the aircraft? Yes, if we consider flying safety as an aircraft. However, in aviation practice, especially military, flying safety determines a high-level achievement of the demanded result, namely, combat efficiency.

If we consider the workstation as a systemic object then, from the flying safety standpoint, the estimation of its efficiency is possible only under conditions of a powerful performance, i.e., by achieving the goal with the aircraft. Hence, it follows, that the desired solution, that would streamline the components and their function, is the process of interaction. This interaction, and the mutual 'adaptation', create a unified systemic property. The adaptation of the technology to man is the 'pole' to which are tied all the structural components and around which their interaction is organised.

This methodological concept means that neither the educated specialist, nor the up-to-date technology can guarantee flying safety by itself, since the system is a holistic, integral education with new qualitative characteristics void of educational elements, when considered independently. Proceeding from the given premise, together with N.D. Zavalova, we came to the conclusion about an insufficient concept of the personal factor, since it ignores man's interaction as the work subject. Without understanding interaction, it is unlikely to establish the relation of the cause and the effect. The principal of the personal factor needs to complement the <u>principle of interaction</u> between man and technology.

The first attempt at the systemic analysis was in the field of engineering and psychological investigation of the 'pilot-aircraft-environment' system. The first success was the discovery of a new class of errors, having a common systemic quality projection errors which are the result of blending man's incomplete knowledge with metal. In the interest of a systemic approach to establish the requirements of the flyer's workstation, we have introduced a new term 'human factor'. We are defining the human factor as something that influences the reliability and efficiency of the interaction between the flyer and the equipment. To this notion we add the idea of a connection between man's performance characteristics and the equipment he uses. This becomes not only indispensable, but also capable of considering the 'error' of the flyer as an <u>integral index of the man-machine interaction.</u>

Therefore, human errors, when flying in an aircraft, have a systemic quality, since they cannot be explained separately by either the human behaviour or by the aircraft's equipment function, and become manifested only during their interaction.

Our 25-year experimental studies of the flyer's performance in an emergency situation, the thorough analysis of mishap causes, the engineering and psychological investigations of the display and control systems have convinced us that the lack of a systemic approach has generated the opinion that deficiencies of the workstation were later interpreted as performance errors, i.e., errors of the operator.

It goes without saying that these are no rash conclusions, but <u>fruits</u> of an extended effort of a large number of scientists, and the analysis results of the not always 'safe' delay of the physiological science. However, it was all very valuable because the ideas were accepted by the former USSR Air Force Headquarters Command and, first of all, by the then Air Force Chief Commander, Air Marshall P.S. Kutakhov, and the Air Force weapon Commander, Colonel-General of the Air Force, Doctor of Sciences M.N. Mishuk. The latter, now deceased, has often noted that, during aviation accident investigations, aircrew errors are

Table 15. Aviation mishaps with fighter aircraft of the second, the third, and the fourth-generations as a function of structural changes.

Flight mission stages	Generation of manoeuvring aircrafts		
	2nd	3rd	4th
Takeoff, circle, flight on-route	3.4	8.5	3.1
Sortie	16.2	15.5	31.1
Combat application	7.3	20.1	29.3
Landing approach	72.4	55.5	35.3

explained by the so-called personal factor, such as malaise or poor flying ability. He was of the opinion, that such an approach does not allow understanding the incompatibility between the aircraft technical characteristics and the psycho-physiological characteristics of the aircrew members. Thus the Pandora's box was opened, but victory was still beyond reach.

4. Efficiency of Ergonomics Applied to the MiG-29

As the responsible person for the technical project and the creation of a MiG-29 test simulator, the Special Aircraft Construction Bureau, named after A.I. Mikoyan, assigned Doctor of Sciences Yu.A. Yanyshev, the Air Force Institute of Aviation and Space Medicine assigned Colonel V.G. Smorchkov, the supervisor of the Air Force Headquarters Command; coordinator of satellite organisations and contractor was A.F. Doctor of Sciences of the strategic weapons, O.K. Rogozin. I was appointed by the Air Force Headquarters Commander as chief scientist responsible for the methodology and the carrying out of the scientific investigations.

The fighter-aircraft MiG-29, on many scores, is recognised to be equal to the best models of the current aviation and technology, and in some aspects it even surpasses USAF technology fighter-aircraft of the same class. This aircraft possesses a high thrust power, an excellent manoeuvrability, and vertical speed which enables the flyer to perform unprecedented manoeuvres (vertical) at takeoff. The power of two turbojets with an after-burner, and mechanised, trapezoid-shaped wing and an automatic pilot control substantially raise the aerodynamic qualities of this aircraft. The high manoeuvrability and automation of this aircraft, the newest optic electronic navigational guidance, and the weapon systems have brought significant changes to the flyer's performance, especially to combat missions. The aerobatic manoeuvres may be accompanied by high sustained acceleration (tenths of a second duration) with +Gz-peaks of up to 9 Gs with an onset rate of up to 4 G per second, which is very close to man's psycho-physiological tolerance limit, placing demands on the health, the functional, the physical and professional preparedness of the flyer. The data presented in Table 15 demonstrate how structural changes are the precursors to aviation mishaps for different aircraft generations.

The methodology we used was based on man's coordination capabilities, resources used by the flyer, conditions of the organisational activity of flying duties, and the probability of attaining the required efficiency and reliability of the 'pilot-aircraft-environment' system. On the simulators, we accomplished purposeful programs: engineering and psychological estimation of the flyer's workstation, flight display systems, control and weapon systems, as well as the training of the flyers for special combat missions. We used the Base centrifuge and computers to study the tolerance of aerial combat manoeuvre accelerations, to estimate the capabilities of the flyer's target acquisition precision during air combat manoeuvres, while donning individual protective garments. We carried out a special investigation of the aircraft ergonomic characteristics, the physiological and hygienic life support parameters, the psycho-physiological peculiarities and the operational unit's flying staff efficiency, during the transition and the acquisition process.

As a result of the implementation of the ergonomic spatial and geometric requirements of the cockpit and instruments allocation, the flyer's interaction with the main control panel was substantially improved in comparison to the third generation aircraft cockpit. We observed a significantly improved out-of-cockpit view, as well as parameter visibility for port and starboard instrument panels. This translated into a 2 to 3 fold reduction of errors by the flyer, as compared to other MiG aircraft.

Thanks to these investigations, we established the peculiarities and the deficiencies of the flyer's workstation disregarded in the technical proposals (draft technical proposals, aircraft mock-up commissioning), which might lead to pilot errors as it became evident during the interaction study between the pilot and the new SEI-31 system. The informational 'pictures' of flight-navigational parameters were radically changed (80 percent). During the government industry tests, 24 proposals for a standard flight display system SEI-31 were realised (V.V. Lapa, I.S. Mikitin, V.V. Migunov, G.G. Skibin). Owed to the timely performed technical investigations in a simulator (after the manufacturing plant tests), an inconsistency with the Air Force tactical and technical requirements was observed. The flyer was able to receive information from the direct vision indicator with the external elimination level of 12,000 Lx, and the head-up display at 40,000 Lx, while the Air Force tactical and technical specifications required an external illumination of 100,000 Lx. As a result, the low quality polychromatic CRT, on the direct vision indicator, was removed and replaced by a new CRT, which allows the flyer to read the flight navigational information at the external illumination levels of more then 80,000 Lx (A.S. Kondratyev, A.N. Razumov, V.D. Suslov, E.V. Alexeyev).

The engineering and psychological investigations of the flyer's interaction with the weapon control system were more promising. The principles realised by the contractor-developer, of the weapon control system, had some psychological defects that lowered flying safety. The originally implemented aircraft aiming procedure for non-synchronous, on-board gun shooting at aerial targets, in complicated meteorological conditions, did interfered with spatial orientation. The proposed concept of 'psy-indication' deprived the flyer of his basic qualities: combine flight control with spatial orientation. The introduction of the aiming concept 'zero-procedure', decidedly improved the reliability of the flyer's performance (N.D. Zavalova, I.S. Nikitin).

Thanks to the carried out investigations, flyers trained on the simulators got accurate and objective information on what they should focus on in their training. The investigations on the centrifuge simulator have shown that tolerance and high professional reliability of the flyer, during exposure to +Gz accelerations of up to 9 G, first of all, required efficient individual anti-G protection garments. In order to realise this, additional research was carried out to further improve anti-G suits. As a result, we develop the new anti-G suit, (PPK-3, with automatic pressure valves), that enhances G tolerance by approximately 1 G. We also developed a special positive pressure breathing system, where the positive pressure valve changes proportionately to the level of the acting G force (I.N. Chernyakov, M.N. Khomenko, A.S. Barer, et al.).

The investigations, carried out in the dynamic complex, evidenced that it was impossible to solve the problem of the flyer's protection against high-sustained +Gz accelerations, onboard the new generation aircraft, with technical improvements only. It was determined that a special training was needed, aimed at enhancing the tolerance to accelerations. A group of experienced, specially trained subjects, the skilful use of the anti-G straining manoeuvres increased the +Gz tolerance on the average by 3.6 Gs (G.D. Glod, R.A. Vartbaronov, L.S. Malashchuk).

We developed and recommended retraining of the operational units during a transitional phase to new aviation technology. The psycho-physiological training included:

- familiarisation with the characteristic effects on the human body by high sustained +Gz acceleration;
- special physical training, directed mainly at increasing static endurance to the lower limbs, muscles, abdominal press and neck muscles;
- improve the anti-G straining manoeuvre;
- teach the operational characteristics of the new anti-G suit;
- theoretical and practical training of safety measures during exposure to high-sustained +Gz accelerations (specifics of self-control during psycho-physiological stress, emergency criteria, and ways to prevent them).

A group of flyers at the Kubinka Air Force Base trained by performing aerobatic flights involving high-sustained +Gz-accelerations, as well as theoretical and practical training, a course of physical exercises on special equipment, and familiarisation training runs on the centrifuge. The two-week course increased the tolerance level to +Gz accelerations in all trainees, up to the desired level (9 +Gz, for 30 seconds, onset rate 1.0 G/sec (M.N. Khomenkko, S.D. Migachov). Before the tests on the MiG-29, we worked out a protocol for prolonged +Gz accelerations up to + 9 Gz for 30 seconds (R.A. Vartbaronov).

A radical approach to the problem would have been to increase the angle of the seat back to 42 degrees, however it turned out to be technically impractical. This was experimentally determined (A.P. Kuzminov). However, we were able to improve several safety systems: a new anti-G suit (PPK-30), a new positive pressure breathing oxygen equipment, providing proper blood supply to the brain, a new anti-G straining manoeuvre, new physical exercises, and a physical trainer, the 'statoergometer'. All this was ready before the delivery of the new aviation technology to the operational units (M.A. Tikhonov, G.D. Glod).

Specialists examined 36 flyers. Ten, (young), turned out to be physically unfit to high-sustained +Gz acceleration due to poor physical condition. Later, a special scientific game was developed for physical training, to correct insufficient physical preparation (V.I. Zorile, N.I. Forlov, S.D. Migachov, M.N. Khomenko, R.A. Vartbaronov, et al.). They not only studied man in the MiG-29 fighter, but also added, to the existing training, new performance techniques. I wish to mention some of the results obtained by our scientists. Methods were developed and approved which allow an indirect (without centrifuge) determination and prognostication of the flyer's individual tolerance to +Gz exposure, by evaluating the flyer's reaction to special stress tests before a sortie. Starting with the acquisition of the new aviation technology, a complex medical team was established to support the flyers during the transition phase. As a result of systematic ground and flight investigations, and in cooperation with about 140 flyers in four Air Force Bases, we performed approximately 500 experiments.

The acquisition of the MiG-29 by operational units has revealed moderate, psycho-emotional stress during the transitioning phase. In the first solo-flight, the greatest psychological reactions were noted before takeoff, landing, and at takeoff from the runway.

Repeated sortie, during the transition program using experienced flyers, were accompanied by a significant decrease in pre-flight reactions, (after 3 to 4 sortie), and an improvement in flight performance indices, levelling off of the performance scores, which usually registered after accomplishing 5 to 7 sorties, and of the psycho-physiological reactions after 8 to 10 sorties.

Therefore, from the rational and the psycho-physiological point of view, the transition to the MiG-29 consisted of 9 to 11 flights, including circling, cross-country, and formation flight. The manifestation of the changes in flyer's psycho-physiological functions, when flying the MiG-29 and performing aerobatic manoeuvring depends, to a considerable extent, on G forces. Increased Gs bring about stronger adverse functional and performance changes.

Based on received data, the scientists organised a special training for the flying personnel in order to enhance tolerance to +Gz. The aircrews received training on the specific reactions of the human body to high-sustained accelerations, as well on means and methods of enhancing tolerance. They carried out complex medical observations of the functional and the physical state of the flyers which helped preparing for the acquisition of the new aviation technology. These observations revealed that 25 to 30 percent of the flyers could not tolerate high sustained + Gz (less than 6 G). Based on the investigation data, each flyer was informed of his potential to tolerate accelerations, and was given practical recommendations on how to increase tolerance. A special physical training of the flying personnel was organised. In time, the aircrew took training centrifuge runs and were exposed to 9 Gs for 15 seconds. The centrifuge training served as a familiarisation with the effects of high-sustained +Gz, with safety and prevention measures, as well as a behavioural training under these conditions.

According to the flyers, this special training not only increases +Gz tolerance, but serves also as an important component for moral and psychological readiness to fly. During the MiG-29 acquisition phase, the issues of the workload standardisation, and of the establishment of the work-rest regime of the aircrew, were very important. They are needed to improve flying skills and flying safety, as well

as to preserve health and longevity. However, training for combat readiness, during the transition and the acquisition phases, did not take into consideration workload norms. In fact, in the early phases, in 62.3 percent of the cases, the flights were carried out with insufficient rest periods, between sorties, for proper functional and performance recuperation time. This was corrected after related data became available. Based on the psycho-physiological investigations, and on comments made by the aircrews, recommendations were made for optimal daily workload limits:

- during the transition phase 2 to 3 sorties, maximum duration 1.5 hours;
- during the acquisition (combat missions) phase, exposure to +Gz of 6 Gs, sortie, maximum duration 2.5 hours;
- during sortie with aerobatic manoeuvres and exposure to +Gz exceeding 6 G, maximum duration 2 hours, including other training flights;
- duration of rest periods between repeated sorties in a transition phase, for functional and performance recuperation should not be less than 60 minutes (V.I. Zorile, N.I. Frolov).

The transition phase to new aircraft showed that 81.3 percent of the quizzed flyers experienced some performance deterioration, if sorties were suspended for more then 6 to 7 days. During the acquisition of the new aircraft and the flying procedures, 79.6 percent of questioned flyers experienced some problems with intervals of 10 to 15 days. They included attention and instrument information perception disorders, spatial attitude misjudgement, poor decision making, and poor performance. It was also established that when sorties were suspended from 2 to 5 weeks, +Gz tolerance decreased from 0.5 to 1 G. However, the level of +Gz tolerance may be restored in 2 to 3 consecutive days of flying. All this should be taken into account in planning missions with high-sustained +Gz after a prolonged interruption of flying duties. To maintain a high-level of +Gz tolerance between layoffs, the pilots must regularly carry out special physical training exercises at the gym.

In the process of professional training the aircrews, while solving other tasks, will not always fly at high-sustained +Gz. However, from our viewpoint, the flight training should be aimed at constant combat readiness to fly at high +Gz. Based on the experimental data, following the flight regime with high-sustained +Gz to retain tolerance, it is necessary to perform not less than four sorties per month, for a total duration of 5 minutes with an interval of 7 to 9 days, of these three with a maximum acceleration of 7 Gs for 15 seconds, and one to 9 Gs for 15 seconds (M.N. Khomenko).

The analysis, of the errors performed during sorties in the transition and acquisition phases, has shown a 10 to 15 percent increase of specific errors during takeoff and climbing. The cause of the problems in the initial phase, in the opinion of the aircrews, is due to the unusual view out of cockpit, which compels to lift the nose of the aircraft, this results in lifting the angle of the nose landing gear during takeoff and, consequently, the angle of climbing. These errors have been observed, independently of the flyer's training level and the pilot's class, for the first 25 to 30 missions during the transition phase. The other characteristic errors on takeoff are not lowering the flaps and repeated deployment of the landing gear. These errors were also distinguished by prolonged negative dynamics and were eliminated after the 20th to 25th mission. This was confirmed by questionnaires.

During sorties in the local area, we saw errors related to gravity increases (+Gz peaks) resulting from air combat manoeuvres. Typical, as in previous fighter aircraft generations, was the recovery to level off from a diving manoeuvre to a dangerously low altitude, as well as loss of speed during the target attack. Performance in the cockpit presented some problems related to the confusion of the "photo-shooting gun" switches and the "shutting off the left or right engine", which were interpreted as 'aircrew errors'. The questioning of all rank flyers has revealed that these errors are rather 'common', due to the fact that the mentioned switches are located too close to each other, and are partially 'shaded' by the throttle. During the taxi run, we observed new errors due to the irrational location of the magnetic radio compass push button. During close-by sorties, cross-country flights and the landing approach, gravity caused errors, in the MiG-29, diminished substantially compared to earlier generation aircraft (O.A. Kosolapov, I.M. Alpatov).

In time, flying safety specialists, analysing the causes of aviation accidents/incidents on fighter aircraft of the fourth-generation, came to the following conclusion: Optimisation of ergonomic conditions in the cockpit of the MiG-29 during five years of its operation, produced a 60 to 80 percent reduction in the number of errors in the flying

units, compared with previous generation aircraft. This led to a remarkable drop of aviation incidents in the fourth-generation, fighter-aircraft operations. In particular, for the first seven years of their acquisition, the total flying time per aviation accident, compared to the MiG-23, was increased more than three times. It should also be noted that the total flying time per aviation accident, caused by aircrew poor performance, increased 2 times. With legitimate pride for the aerospace medicine of our country, I wish to quote still another impressive fact. In the USAF, from 1982 to 1985, there were 36 major aviation mishaps with the fighter aircraft F-16, due to loss of consciousness and acute incapacitation of the pilot. In the Russian Air Force, for seven years of fighter-aircraft MiG-29 operations, there were only four minor aviation incidents. The success of the aviation constructors is shared by the flyers, the aeromedical scientists, the aviation physicians, the engineering psychologists, and the ergonomic engineers. But the main conclusion rests in the fact that flying safety can be better served when man is at the centre of it, with his right to life.

CHAPTER 5

PREVENTION OF DANGEROUS FLIGHT FACTORS

Prevention is an important consideration. From the 1960s to the 1980s, the problem of information secrecy was a security deterrent factor. This applied mainly to flying academies. As a result, new aviation technology arrived to the operational units before the training manuals. It should also be pointed out that all the deficiencies, not eliminated during flight tests, were hidden in the so-called operational limitations. Even the test pilots were practically deprived discussing the 'flying applications' of the new aircraft. Previous experience, combat and retraining centres allowed the flyers to make up for lost time. However a prevention of aviation incidences was often replaced with limitations and prohibitions. And this lowered reliability, as the flyers noted on the questionnaires that I gave them.

Aviation medicine, a speciality concerned with the well being of flying personnel, was in its infancy. From 1967 to 1977 our aviation industry was in the 'imitation mode' of flight instrumentation and cockpit design. However, at this same time, in the American aviation magazines, the problems met during the acquisition of the new technology were openly discussed. The experience of foreign Armed Forces was insufficiently used, except for the tactic and technical characteristics of their aircraft (required for exams). Their experience had a lot of surprises; moreover, some leaders had formed a somewhat wrong idea about the excellent American technology. This was due to our informational services spreading advertising data from the American press, where the aircraft manufacturing firms lauded their products to the sky before the Pentagon. But, in actuality, not all the reviews were correct, at least, not from the viewpoint of ergonomics [Ergonomic, 1980, Vol. 23 (10), pp. 95-1101]. All this created the prerequisites not to learn using ones own mistakes. I will cite some passages from a special lecture by Professor I. Statler – Ergonomics of the military pilot.

Analysing the construction features of the aircraft cockpit, Statler has concluded that the engineers/developers did not comprehend, or even ignored, the fundamental requirements related to the receptive organs, and the limitations they place on man. Research and development and the experimental construction work should be targeted to solve three problems: flyer's workload, human performance, and training methodology. The tactical, fighter-aircraft cockpit design has been determined by two controversial trends of modern military aviation. The physical size of the cockpit has been diminished, while the volume of information, which must be displayed to the aircrews, as the number of control systems has been growing exponentially. Electronic systems, developed initially to alleviate the flyer's workload and to facilitate his work, may actually only complicate the conditions of his flying activity, since they receive and treat a huge amount of flight information. As an example, I cite the F-18 cockpit, which our information services extolled to the sky. I visited the USA and some of their air force bases where I had the occasion to see the cockpits of the F-15, the F-16 and the F-18, though, to tell the truth, I was not enraptured with their ergonomic qualities. In order to be impartial, I will cite the expert opinion of an American colleague. Simultaneously, I would like to point out, once more, that this is not a discussion about advantages or disadvantages of the F-18 fighter aircraft, but only about the work conditions of the military flyer, i.e., about ergonomics only.

The cockpit head-down instrument panel of the F-18 fighter aircraft has three multi-functional display systems, each of which has 20 programmable switches. On each of the three multi-functional CRT screens, are traced out 675 abbreviated signs and conventional designations. Moreover, 177 various symbols are displayed, each of which may be presented in four different sizes. There are also 73 warning signals of dangerous situations and recommendations, 59 light signals, and six sound signals of danger (not verbal). An additional 22 separate configurations, (on the head-up display [HUD]), are provided which use the same basic symbols, but they are located in various parts of the informational field. On any of the three CRT screens, 40 various formats may be presented. The HUD panels provide control with two UHF/SHF radio stations, steering for instrument landing, a radio navigational system TACAN, radio beacon, automatic radio bearing finder, 'friend-foe identification' system, and automatic pilot performance. On the throttle (located left) are provided nine switches, most of which are

multifunctional, and on the control stick (located right) are seven more switches.

Let us now visualise the poor pilot of the F-18 fighter aircraft during a flight combat mission, at an extremely low altitude and at a high speed in an unpredictable front-line situation, or in actual combat with targets against the background of intrusive enemy electronic counter-measures. Is he really capable to memorise and instantly retrieve, ex tempore, all these symbols, signals, signs, etc., in a situation of combat fascination and emotional outburst? Such cockpits would be incredibly beautiful if the aircrew were composed of two pilots, a flight engineer, a weapon operator, a navigator, an avionics specialist, and a translator. Regretfully, the entire aircrew of the F-18 consists of only one person, while the complexity of on-board control systems is enormous.

Some 3 to 5 years after the USAF acquired aircraft with electronic systems of flight information presentation, we faced the same problems. But, our first investigation results refuting the foreign advertising articles regarding the electronic indicators, especially the HUD, were interpreted to be discrediting the new military technology. I will cite below some of our experimental investigations. HUD findings also noted that the CRT flight displays, of the type 'integral cockpit', had been sprung on the unprepared flyer because of a complete lack of teaching technical supplies. Of course, all this is now in the past, and we hope it will not once again in the future. To demonstrate the informational 'starvation' and its destructive effect on teaching and training, I will quote some American aviation papers published in the '80s, which will hold true to the year 2000.

1. Characteristics of the Current USAF Accident Rate

The history of aviation mishaps in the USAF is deeply rooted in the distant past, long before the aircraft were produced for large-scale use in the Army. The first U.S. military aviation mishap, involving power flight, occurred before the Army even owned an airplane. The crash was at Fort Myers, Virginia, on 17 September 1908. The occasion was the final flight in the acceptance trials of the first aircraft purchased from the Wright brothers.

Lt. Thomas E. Selfridge was flying with Orville Wright. After they had been airborne for about three to four minutes, the aircraft suddenly nose dived and crashed. The tragedy of this accident consisted in the fact, that the first time this plane was flown by a military pilot and just in the first flight, the pilot was killed. During the investigations of the accident, and questioning of eyewitnesses, it was found that the cause of the mishap was a contact of the rudder with the propeller, consequent loss of manoeuvrability, and crash. The changes introduced by the Wright brothers in manufacturing aircraft in the USA are considered as the milestone of all the future programs of flying safety enhancement.

According to publish data from 1911 to 1914 the, the U.S. Army Signal Corps registered 11 major mishaps, which involved loss of 14 aircrew members, including 12 commissioned officers, 1 non-commissioned officer, and one civilian.

From 1921, the Army began keeping track of the accident rate. In that year, the Army flew 77,000 hours and had 361 major accidents. When we convert this to today's rate, it equates to 467 accidents of class 'A' per 100,000 flying hours. If this were the case today, the losses of the three major aviation services, the USAF, the U.S. Navy, and the U.S. Army could reach 1350 aircraft per month, and the entire aviation military inventory would be irreparably lost in 7 months (Flying Safety, June 1988, pp. 20-24). A remarkable fact in 1922 was the first United States Navy air carrier takeoff (Flying Safety, September 1988, Vol. 27). At the height of World War II, the U.S. lost a large number of aircraft and flyers in combat. These losses were tragic, but even more tragic was the fact that the U.S. military aviation had lost more men and aircraft, in not combat flights in the continental U.S. than they had lost in the battlefields.

The darkest year in the U.S. military aviation history was 1943 when, in the continental U.S., 20,399 aviation mishaps occurred with a loss of more than 5600 aircrew members. In that same year, in non-combat flights, 1100 servicemen were killed and 1200 aircraft destroyed. For a total of 32 million flying hours for that year, the major mishap rate was 64.0, and the daily losses of aircraft reached an average of 56 (Wings of Gold, 1988, Vol. 13,N2).

Important changes at the end of the 1940s were introduced in the U.S. Navy aviation. Sophistication of aviation technology, introduction of the 'trampoline' on carriers, and optical landing

guidance systems, all greatly decreased the aviation accident rate at the beginning of the 1950s (50.0-55.0). The sharp drop in the U.S. Navy aviation mishap rate was stipulated by the changeover of propeller-driven aircraft to jet aircraft, and the acquisition of helicopters (Air Force Magazine, 1986, Vol. 19, N1).

In 1951, the U.S. Navy established an aviation Safety Department which, in 1955, became the Flying Safety Center tasked with the solution of control, maintenance, operation, servicing, and materiel supplies. The U.S. Air Force recognised that an effective safety program needed trained specialists. Therefore, in March 1953, a special School of Aviation Safety was established at the University of Southern California. This was the only school of its kind in the world.

With the appearance of the new generation aircraft such as the F-15 and the F-16 in the USAF, and the F-14 and the F-18 and U.S. Navy, outlines of stricter requirements to flying safety were drawn up. For the first eight years of flying operations, there were only 11 mishaps with the F-18, moreover, in 1982 there were no registered accidents. This was unprecedented for combat aircraft. The USAF flying safety, based originally on 'prohibition principles', started to search for more efficient, as well as safer means to accomplish their missions. The planned measures lowered the aircrew mortality rate and promoted better performance and safety. The USAF Headquarters Command had relaxed the requirements for flying safety with requirements for enhanced combat readiness. The USAF flying safety specialists observed a lower accident rate during updating of aviation technology with increased operational use, implementation of stricter flying personnel training, with greater realistic combat conditions. Nevertheless, with equal flying time, the F-15 had a two-time lower accident rate compared to the fighter aircraft of the previous generation (F-4), while the accident rate for the F-16 fighter aircraft (7.2 at the beginning of 1986) is the best safety index for single engine fighter aircraft of the USA.

The main factor promoting improved USAF, U.S. Navy, and U.S. Army flying safety was the readiness of the entire aviation personnel to communicate anonymously about all dangerous flight situations which were then summed up and analysed. This represented acquisition phase experience and offered direct information of possible dangers. The total number of military aviation accidents in the USA are usually separated into two main groups, according to the factors which cause them: accidents resulting from aviation technology failure, and accidents due to human error.

The greatest technical and manufacturing problem was engine failure, which caused approximately 1/2 of the aviation accidents. One-third of all aviation mishaps concerned engines F-100 and P-200 for the F-16 fighter aircraft. Currently, the solution for further lowering accident rate is linked mainly to the human factor. Pilot error remains a virtually unchanged problem. In the last five years (1983-1987), 14 fighter aircraft A-6E were lost due to crashes; all aircraft were in good working order. In 1986 about 50 percent of aviation mishaps of the U.S. Navy resulted from pilot error (Air Force Magazine, 1986, Vol. 69, N1). The main factors were: pilot's loss of concentration, lack of altitude control as well as spatial disorientation. Additional contributing factors are fatigue, heavy workloads, excessive stress, etc. An analysis of the prevailing causes has been found to be at least two of the enumerated factors.

Nevertheless, there is one contributing factor to aircraft crashes and control losses not directly related to pilot error. It is the +Gz induced loss of consciousness. The aircraft of the former generations were not built to sustain high accelerations. The modern aircraft, equipped with electronic control systems, can reach and sustain high accelerations with a minimal pilot effort on the stick, therefore, man is now the weakest link in the 'aircraft-pilot' system. The absence of accidents is defined, to a large extent, by the intensity of the aircrew flying activity, including the monthly flying hours. The U.S. Navy specialists suggested that a decrement in the flyer's monthly flying duties to 21 hours might influence the accident rate. Furthermore, the specialists could not yet determine the workload per pilot, flying one or the other type aircraft, to guarantee the required level of professionalism. In the USAF, the flying training of aviation cadets is considered to be insufficient. The total flying experience of an USAF graduate cadet has been reduced to 175 hours (the Russian Air Force down to 50 hours). Lack of experience increases the probability of aviation accidents in the younger military flyers. The increased uses of flight simulators can not solve the problem, since these devices can not fully duplicate the conditions encountered by the trainee in actual flight. According to the USAF Headquarters Command,

one-hour in the flight simulator does not correspond to one hour of actual flight missions. Therefore, the question emerges of the cost between actual flight training and potential losses of in-flight accidents and cost of providing flying safety.

The main source of aviation accident information causes is the on-board recorder. According to the analysis by the flying safety specialists, about 7 to 15 percent of the major aviation accidents could be prevented, if information were available about earlier aviation accidents, which is practically unattainable due to classification. If in Russia the data in the 'black box' of the crashed airliner TU-154 in Krasnoyarsk had been available to the civilian aviation community, it would have been possible to prevent an analogous aviation accident with the TU-154 at the Irkutsk air terminal. I should like to emphasise the greatest achievement of the Flying Safety Service of the USAF, where a highly qualified staff of more than 2000 specialists has improved aviation accident prevention for all type aircraft, including the projected ones. The progress of the computer technology broadens substantially the capabilities of this service, as well as prevention and prognostication of potential accidents.

The goal, formulated by the USAF Headquarters Command to further decrease the aviation accident rate for class 'A' mishaps, to an annual average of 1.25 per 100,000 total flying hours, for the entire aircraft inventory of the 1990s, is noble, and lies within the bounds of possibility.

2. Leading Factors Threatening Flying Safety (Review of foreign data).

In the previous chapters, by expounding some of the issues, I have tried to generalise the theoretical and experimental data. In this chapter, it would seem reasonable to consider some foreign literature on flying safety. I would like to draw attention to the style, i.e., freedom of thought, independence of opinion, excellent knowledge of subject matter, clarity and simplicity of expression. The data are fragmentary to allow each reader to draw his own conclusions.

1. Interview with Lt. Gen. Robert W. Bazeley, Inspector Gen. of the U.S. Air Force; command pilot and navigator with more than 4,500 hours in a variety of aircraft (Flying Safety, 1984, N1).

Question: For the past two years, the USAF has set new records in reducing class 'A' aircraft mishap rate. What do you see as the reasons for this success?

Answer: There are numerous reasons, as this is an evolutionary process over many years. When I was a young fighter pilot, the accident rate was about 55 per 100,000 flying hours. We had about 2000 fatal accidents a year, and that was a tragic loss. Since then, which includes the beginning of the jet age, the rate has been gradually going down and last year, 1982, it was 2.33 per 100,000 hours. But how has it happened? The reasons are many: improved design of the aircraft and of its reliability. Our safety program starts with the concept of a new aircraft and its design. The representatives of the Aviation Safety Service are involved in the total process, i.e., they follow the system from start to finished product. One critical area is the discipline. Modern aircraft, their weapon systems and missions are very demanding.

Question: As the Inspector General, you are very concerned about how the Air Force maintains the capability to perform the mission. What do you see as flight safety's contribution to readiness?

Answer: An exciting element of where we are and what has happened, say, over the last 35 years, is that along with the tremendous safety improvements, which have saved us lives and resources, we have also continued to improve the training of aircrews by making it more realistic. We train them in the way we expect to have them fly. There are other programs, such as the air combat manoeuvre instrumentation range, where we can place aircrews in a mock battle mode, and train them in a realistic wartime atmosphere. After the flight, the new technology enables us to carry out accurate critiques, which tell the flyers who won and who lost. Missions in the last years have increased, but accidents have decreased. This raises substantially aircrew readiness. In the mid-1950s we were destroying something like two aircraft a day. That was a terrible loss of resources. Quite often we lost the pilot because the egress systems were not nearly as good as they are today. With each pilot, we lost all the training and the experience we need for the future leaders.

Question: In recent years, mishap statistics have indicated that human error, rather than the equipment failure, is the major cause of flight mishaps. What are your thoughts on how we can attack this problem?

Answer: We must consider the physical and psychic stresses present during flight missions. We don't want our aircrews to be robots or machines. They're human beings; they have families, children, and problems. We want them to enjoy their lives and not be just dedicated to fly aircraft in combat. We can not control a pilot as a machine. We have to always consider the human factor. We need to impart the necessary knowledge to the flyer and make sure he does not deviate from the established norms. Much of this is a matter of personal commitment.

Question: Which are the flight safety issues on which commanders and aircrews should concentrate their attention?

Answer: Human factors. We cannot forget other factors, this is fundamental. In the last years we have lost many experienced pilots. Now we have many young, well-trained, and dedicated airmen, but they do not yet possess the necessary experience.

Question: What plans do you have for new initiatives of aviation safety as the Inspector General?

Answer: One of our goals is to improve selection and education. Studies for this purpose are carried out in our country, as well as abroad. We don't have a structured process for a proper selection screening process.

Let us now consider the thoughts disclosed by USAF Major General Roy De Hart, M.D., on the role of the human factors at the Tactical Air Command (ASEM, 1986, Vol. 57, N7). The workload and the psychological stress experienced by the modern flyer are enormous. It was just yesterday that the specialist was worried about the possible technical problems of "aircraft exposure to very high accelerations", and now every Flight Surgeon is worried about the unfavourable effects of the excessive G forces on the flyer's body.

The most urgent problem of the human factor in tactical aviation is the loss of spatial orientation, along with a loss of consciousness due to high G forces. Spatial disorientation is responsible for 30% of major aviation accidents related to the human factors, (fighter-aircraft F-16), and 19% for aircraft F-15 and F-4. Amid other factors are the loss of concentration, tunnel vision, loss of situational awareness, and visual illusion. These are frequent and concomitant factors of aviation accidents in the Tactical Air Command. If we were to arrange these factors in order of importance, acceleration should be problem No.1. In 1981, the outdated system of medical selection, based on the principle "flies one – fly all", was replaced by individualised medical expertise. However, for some years, the Tactical Air Command ignored the recommendations of aviation physicians of training flyers by exposing them to high-sustained +Gz.

Dr. Roy De Hart believes that pilots of the Tactical Air Command can efficiently fly aircraft during a short exposure to 9 +Gz if they pass the selection and receive the necessary education and training. The pilots should have a profound understanding of the psycho-physiological factors of spatial disorientation, of physiological aspects of high G forces, and of individual physiological phenomena of man in flight. The specialist of aviation safety includes spatial disorientation among the dangerous factors. I will mention here two papers of foreign specialist, in particular, M.B. Marlowe's (Flying Safety, 1985, Nov., pp. 13-16).

The results of many aviation accident investigations have evidenced that spatial disorientation may be unrecognised if the flyer is distracted, troubled, or anxious. The flight of some fighter aircraft may be so smooth that the flyer can not hear the noise of the engines and the aerodynamic drag and, perceive the sensory stimuli, (the so-called 'aircraft sensation') he should feel on the control stick, the pedals, and the throttle. In Table 16 are some data of the USAF aviation accident statistics.

There are three known types of spatial disorientation: full incapacitation of the flyer's ability to handle the aircraft, partial recognition of potential spatial disorientation, and unrecognised spatial disorientation. The loss of spatial orientation requires emergency ejection when the sense of the inner 'gyroscope' is unable to effect recovery. Spatial disorientation occurs rather often, but usually is short-lived and resolved by correct validation of visual stimuli (cross-checked comparison of flight display indications). The unrecognised disorder of spatial orientation is of special concern. It is the most common form of spatial orientation loss, which leads to aviation accidents, and its elimination is one of the effective ways to drop the accident rate. When the pilot is flying, he uses two modes of visual information perception with the aid of the central and the peripheral vision. Usually, central visual information is perceived independently of the

Table 16: Data of USAF aviation accidents, caused by spatial disorientation from 1971 to 1985.

Type of fighter-aircraft	Total number of cases	Related to aerial combat manoeuvring
F-16	57	26
F-15	47	25
F-4	282	138
A-10	45	36
A-7	82	46
A-5	22	13

peripheral vision. The first mode of visual perception is used for target recognition and visual reading of the HUD. Thanks to this information perception, the brain provides the pilot with the most detailed data.

The peripheral visual perception allows the flyer to detect such clues, as the lines of an actual or a false horizon and to maintain spatial orientation without thinking about it. This is the so-called area of our subconscious, which is in charge of various sensory stimuli coming from the peripheral visual zone, the tactile sensitivity, the hearing, and the vestibular apparatus, enabling the flyer to orient himself by the horizon. The speed of information transmission differs for each mode of visual perception: the 'central' visual function is slower in comparison to the 'peripheral' information treatment, since it demands active thinking. Though more rapid, the peripheral visual perception is less reliable as, for example, at night or with poor meteorological conditions, in the absence of visual reference cues. Therefore, this mode of peripheral visual cueing may function in situations with limited input information, which is handled at the subconscious level. In some aircraft the flyer does not sense some signals, which could alert other components of the 'peripheral' mode of incoming information treatment warning him about an unusual spatial attitude. If the flyer can not switch in time to the autopilot, spatial disorientation may remain unrecognised. The flyer should keep in mind that processing incoming visual information is automated by the peripheral and not by the central vision. The flyer sees what he expects or wants to see. This may happen when a flight is no longer visual but not yet instrumental, which occurs during switching the attention from crosscheck to something else, increasing the chance of spatial disorientation.

Sleep deprivation and chronic fatigue aggravate the occurrence of spatial disorientation and may provide distortions in time perception. The time is perceived as extended. Some seconds may appear to the flyer as minutes, and he has the sensation that there is still enough time to accomplish his mission. The flyer is unaware that his performance has decreased, and he steers his aircraft purely instinctively by "the seat of the pants".

The understanding of fly conditions, which might prompt spatial disorientation, is important, but not sufficient to warrant reliable orientation in the flight situation. It is reasonable to regulate, in good time, the cockpit illumination and to check the indications of the autopilot. These precautions may help the pilot to recover from an abnormal spatial attitude. As for the cockpit illumination, are procedures for the preparation of pre-planned flights. At first, one should switch on the bright illumination, and then, dim it to a comfortable level. The dim illumination in the cockpit eliminates light spots, which impede the pilot's ability to check reliably the flight parameters on the displays. The dim illumination helps the flyer's night adaptation vision. However, in a spatial disorientation event the flyer needs to see more clearly the indicators, but lacking luminosity may confuse the instant scanning and seizing of precise indications. Virtually, in all fighter aircraft, the brightness regulators for intra-cockpit illumination turn out to be peculiar 'decoys' located in places inaccessible to the flyer or require complete distraction from steering. The slightest head movement or change in body position, when the flyer senses spatial disorientation, may become the 'last droplet' in a chain of the spatial disorientation event. Apart from this, the brightly illuminated instrument panel, or the head-down display board, may intensify the blinding effect of the flyer's

cockpit canopy. Reflection of port or starboard panel to a simple head movement, in a brightly illuminated cabin, may be perceived by the peripheral vision as movement, which can disturb, or even stop, the crosscheck of flight indicators.

During formation flight, the flyer should avoid excessive and violent head movements. If a wingman experiences spatial disorientation, the pilot should inform him at time intervals, about the real flight situation. He [pilot] should avoid all accelerations and barrols. Any unexpected and not pre-planned manoeuvring of the aircraft may further disorient the wingman. One should also keep in mind that this wingman is incapable to recover autonomously and needs support from his leader.

The spatially disoriented flyer should force himself to crosscheck the readings of the instruments. He should mobilise all his will power to recover from a difficult situation. But if he is unsuccessful and the aircraft becomes uncontrollable, the flyer should take the decision to bailout, even if he is below the safe ejection altitude.

I wish to add that, the loss of spatial orientation is a normal physiological reaction. The flier must not suspect that he is sick when he is faced by this phenomenon. In this case, it is a matter of ergonomics, therefore it is important to point out that the causes facilitating the partial or complete spatial disorientation, may be related to cabin configuration and equipment design. This will be considered in a later chapter. I would like to mention an example of spatial disorientation experienced by an F-16 pilot, as it was told me by flight surgeon Geoffrey B. McCarthy (Aeromedical and Training Digest, 1990, July, Vol. 4).

Fighter aircraft F-16, built by "General Dynamics", is a unique aircraft, accepted air forces throughout the world. Its construction characteristics are based on the experience the USAF acquired during the Vietnam conflict, which led to a more manoeuvrable and simplified aircraft. It is a lightweight fighter, has high aerodynamic manoeuvrability, and thrust capable of sustained +Gz up two 9 Gs. The out-of-cockpit view is very good; the canopy is all glass without a supportive frame. The cockpit is equipped with a fast operating on-board computer with fully integrated systems. For combat application tasks, the flyer needs to switch only one toggle in order to change area combat (interception) format to a format for a ground target attack. Although the F-16's sophistication provides substantial air superiority, they simultaneously the flyer faced a set of complex aeromedical problems. Among them is the problem of the flyer's spatial disorientation. For the last ten years, from the time this aircraft became operational in the USAF, 58 percent of the total aviation accidents with the F-16 (as of October 1988) were related to human factors. The urgency to solve this problem was imperative, as 83 percent of all spatial disorientation events resulted in the death of the pilot. Spatial disorientation is the second leading cause of catastrophic aviation mishaps, after combat high G manoeuvres causing loss of consciousness and total incapacitation of the flyer, resulting and 100 percent fatalities.

It should be noted that some special features of the F-16 cockpit promote spatial disorientation, and aircrews should be made aware of this. One of the factors increasing susceptibility to spatial disorientation on the F-16 is the unlimited out-of-cabin view. This type cockpit, from the viewpoint of combat efficiency, is definitely most important: "poor visibility – lost aerial combat!"

However, the monolithic construction of the fighter-aircraft F-16 glass canopy, simultaneously impedes pilot estimation of visually perceived spatial attitude. Having lost spatial orientation, the flyer of the F-16 cannot recover without the help of cues. Additionally, a bright panel or console increases canopy glare, especially at high levels of illumination or brightness. At the same time, attempts by the flyer to dim the illumination interfere with the instrument cross check.

The small F-16 cockpit is a further drawback of the flyer's workstation. You can be easily convinced of that by sitting in the cockpit. The distance between the control stick and the right wall, at the lower edge of the canopy, is no more than a fist. The small working area is the reason for the diminished navigational instrument panel and, consequently, the size of the instruments. At the centre of the instrument panel is a large HUD. The main flight instruments are located beneath the HUD, and their size is less than the traditional instruments. The spatial attitude indicator (artificial horizon), combined with the directional display, has a diameter of only 5 cm. It is low on the panel, beyond the flyer's line of vision. The viewing of these instrument displays is very restricted and may prevent a rapid recovery from an abnormal spatial attitude. The diameter should be 6 cm.

There are also problems with the HUD, although it is placed in the flyer's line of vision, well centred and symmetric. However, the ladder-like scale for presenting and reading pitch angles to an 'inside-out' reference system (a movable aircraft index-moving earth horizon line in roll and pitch axes) looks the same, when the aircraft is climbing up with a left bank angle at 45 degrees, and when the aircraft is upside down and diving with a right bank of 135 degrees. This deficiency creates an incorrect estimation in spatial attitude on the HUD. It should be mentioned that this type of indicator in the 1970s had been insistently imposed to us with substantiation on advertising booklets and posters, and became famous at air shows of aviation technology.

To fathom the significance of this fact, let's analyse the case of one of the latest aviation accidents involving an F-16. The flight was performed at night, in clouds. Penetrating the clouds, the flyer put his aircraft in a spatial attitude position upside-down diving, that is he found himself in a climbing path with left bank. Observing the aerial situation to the glass canopy, he collided with the ground. Retrospectively, the following may be assumed. The flyer pictured the aircraft's spatial attitude position based on the scale in coordinates of the immovable aircraft index, probably, coincided with external view of scale, as may happen while climbing with a left turn. The fatal 'recognition' of the aircraft spatial attitude on the HUD or more exactly, confusing diving with climbing, drove the flyer to the grave.

The side stick can be displaced up to 1 cm. This means, it can be moved without the effort and the amplitude required for standard aircraft controls. It should be mentioned that the side roll does not provide the flyer with non-instrumental feedback signals, which he senses when working with a standard control stick. These circumstances practically deprive the flyer of a whole set of non-instrumental signals about his spatial attitude in flight. His body perceives these signals through muscular and joint or proprioceptive sensations, including lower back ('pants') and thighs. The fighter-aircraft F-16 is a 'silent' aircraft. These particularities of the latest F-16 aircraft became the cause of another flying mishap.

Finally, one more peril on-board an F-16 is dizziness. Virtually, all flyers, without exception, experience giddiness provoked by incessant head movements, which stimulate the vestibular apparatus of pilots and generate illusions.

The cockpit of the fighter aircraft is crowded and narrow; the switches of the on-board computer and of the oxygen pressure regulator are on the side panels, far behind the seat of the flyer. In the case of an on-board oxygen equipment failure, the flyer needs to turn his head and his torso. One other deficiency is a poor construction of the computer. When, one of the four computer channels fails, one can not activate the wheel brakes. Moreover, one does not know which brake wheel has failed. And, in order to check it, one needs to turn backward and press the key of the on-board computer on the left panel.

The F-16 is the most manoeuvrable, comfortable, efficient, single-seat combat aircraft of the latest generation of fighters. Although I have focused my attention mainly on the spatial disorientation of the F-16 flyer, my experience has been the same with other type aircraft. Each flyer should know all the capabilities and limitations of his aircraft. A prepared flyer is one who is thoroughly familiar with his plane, and is capable of coping with any of its limitations, and is constantly aware of them. The F-16 provides the competent flyer with an incredible power. But he demands careful care, awareness of all its shortcomings in order to adequately ward off any unexpected event. This skill stands between success and failure. I collected these data in 1990, when I lectured on the psycho-physiological training of the American flyers.

Considering that one of the most dangerous aviation factors is spatial disorientation, it is necessary to expound, for the present and for the next generation, a brief history of the development of the display systems in the CRT, and the spatial attitude indicators. This history is directly related to flying safety. In the former Soviet Union, at the end of the 1940s and beginning in 1950s, in both military and civil aviation we had the so-called direct information of the aircraft spatial attitude, "fixed aircraft index, and moving horizon line". From 1952 to 1962 there were approximately 300,000 spatial disorientation events with different outcomes for the aircrews. Below are the results of the experimental investigations, on this problem, carried out by N.D. Zavalova, (chief scientist); N.I. Boiko, V.V. Davydov, I.S. Nikitin, A.N. Razumov, R.I. Brusnichkina, A.A. Oboznov, test pilots; A.A. Arbeniv, G.B. Skibin, I.P. Volk, V.V. Migunov, A.A. Fedotov, N.I. Stogov, V.M. Gorgunov, O.N. Antonovitch, V.Ye. Minitsky, et al.

3. Results of the Investigations of the Flight Parameters Display on the CRT

The CRT displays have been gradually introduced into aviation. If in the 1960s the only display on a CRT was a radar aiming sight, now the military aircraft are equipped not only with a HUD, supplying flight and aiming information, but also vertical attitude indicators eliminating the electro-mechanical flight instruments. It is pre-planned to install on the fourth-generation aircraft, up to five displays on the CRT: the HUD, the vertical and horizontal attitude indicators, engine regime, and main control display. Individual electro-mechanical instruments are proposed to be used as backup systems. The ergonomic data interfered with this recommendation.

In 1960 and 1970, the trend abroad was to replace the usual instruments with CRT displays. Let us dwell over the main reasons for the transition to the new instrumentation. Technology sophistication increased the number of flight parameters. This, on one side, led to a greater total number of indicators and, on the other, insufficient information during complex flight conditions (low altitude search for small ground targets, other tactical regime, landing under poor meteorological conditions, and different emergency situations). In the mid-1950s a purely technical issue arose, (arrangement of all flight indicators on the extremely restricted area of the instrument panel), as well as a psychological one (combination of instrumental and visual information). In the mid-1960s, basic groundwork became available to solve both problems – progress in electronics. This implied the development of a reliable CRT for the display of any visual symbology for analogue and digital systems to be installed on-board aircraft and capable to analyse and display flight parameters. The transition to screen displays meant not only a change in the type of the display, but also the implementation of complex digital programmable display systems. In these systems, the central computer, with special software, controls the indicator according to the required regime and the observed function. The computer program provides recall by separating incoming information from various sensors in a time-sharing mode. Information is displayed on the indicators, only at the required volume and at the corresponding moment of time. This allows using a large amount of the space available in the cockpit.

It is important to note, that at first, the published discussions, about the functions of the screen indicators, focused on the flight visualisation concept which, it seems, helps to implement the screen indicators. I discussed the so-called analogues of visual flight images of "road in the sky", and television presentation of the external space. It was assumed that the CRT would principally modify the mode of the flight information display and the structure of the pilot's performance, (perception and treatment process), to resemble the characteristics of instrument and visual flight. However, in the early 1970s, it became obvious that with the aid of the currently existing CRTs, it is impossible to obtain the picture which the flyer sees through the glass canopy. Moreover, a modern aircraft calls for quantitative instrumental information. These two circumstances have, probably, compelled the construction of the screen displays which, on the principal of flight information encoding, are similar to standard pilot electro-mechanic indicators, i.e., flight information is displayed on the CRT in the form of scales (instead of round gauges); they are linear, while the digital indicators of the parameter are numerical. In the absence of principal differences, the screen indicators bring about changes in the information display, which can not be ignored in estimating the flyer's interaction with the flight informational systems. Allow me to list the basic CRT indicators, which the flyers must restructure for the perceptive and the cognitive processes (perception and decision making):

- on the HUD, instead of neutral background indices and scales, are important signals about the external environment;
- on the vertical display one can use, as a background, the television picture of the external environment;
- information of all flight parameters is displayed through shining marks;
- during a flight it is possible to change the format of the indicators, the scale dimensions, and the form of the indices;
- it is possible to combine two important flight parameters;
- it is possible to substantially increase the information on the restricted area at the expense of signal display, using time-sharing, and condensing scales and indices on the screen.

I will try to explain, what this means for the flyer. The combination in one spatial field of two types of information, actual and instrumental, is the most valuable innovation afforded by the screen indicators. However, this interferes with the organisation of search information selection of the most important signals, and intensifies the reception and the processing of the information. This, in turn, increases aircrew and signal display requirements. The display of signals on lighted scales, indices, and symbols creates a technical problem of illumination brightness (similar to external conditions), contrast of images, and colour of indices. Because of the significant fluctuations of the external illumination level, (from night to daylight), problems may arise unless corresponding illumination changes are provided. Changes in content information, display format, and scale dimensions, during the transition of one phase of flight to another, demand greater concentration and memory from the flyer. Flexibility of screen indicators, i.e., the ability to display information on a time-shared basis, rapid rotation of encoding synonymous signals, allowing maximal use of the instrument panel, eliminating to some degree, redundant information, creates additional psychic workload and additional decisions related to display signals of one or another regime indicators.

On the initiative of the Aviation and Space Medicine Institute specialists, (chief researcher N.D. Zavalova), jointly with the Air Force Engineering Academy, named after Professor N.Ye. Zhukovsky (chief researcher, V.A. Tuvayev), with the Air Force and the Aviation Industry Department of Flight Testing Institutes (chief researchers, V.I. Levitskas and E.P. Alexeyev), with the Georgian Academy of the Institute of Sciences of Systems Control (chief researcher, N.Sh. Kiladze), with the Scientific Production Association "Electric Automatisation Devices" (chief researcher, J.Z. Lvovsky) have all concurred in a thorough scientific supervision for 15 years, of the new indicator principles. From 1964 to 1968 more than 10,000 tests were performed with more than 100 test pilots. The test pilots were G.M. Shiyanov, N.A. Zamyatin, I.P. Volk, V.P. Vasin, A.N. Zhiltsov, V.Ch. Mezokh, V.V. Migunov, S.V. Khraptsov; the test engineers were A.L. Avayev, Yu.V. Saltanov, A.S. Lisichkin, the test-physicians A.N. Razumov, B.L. Gorelov; the test-technicians were L. Zyabkina, G. Tikhomirova, et al. These were the years, when on the then still experimental aircraft MiG-27, MiG-25, Su-25, Su-17, TU-95, IL-62, TU-154, and others, we were encouraged to install American and French equipment, as the highly advertised multi-functional CRT, instead of outdated flight instrument panels. However, the Air Force engineering and psychological research teams conducted a series of experiments to:

- understand the physiological inhibition mechanism experience by the flyers using screen indicators, and to develop recommendations to surmount it;
- determine the scope of the screen indicators application, and their role in the information system.

We did not evaluate the indicators per se, but their influence on piloting combat applications, flight safety, and flyer's performance. The basic experiments were conducted on simulators, aircraft laboratories, and fighter aircraft. The data received with my participation may be summarised as follows. The investigations revealed some psychological mechanisms of inhibition occurring during the transition phase to indicator systems. We also found data characteristic of the pilot's visual analyser functional state, during CRT information input. There was no harmful effect on the health and the flyer's performance. We made recommendations for the optimal illumination for the head-up and vertical indicators. Let me dwell on the main results of our investigations. Flyer's interaction with the HUD was studied based on circumstance: the HUD should be used when the pilot needs, simultaneously the actual and the instrumental information. The first series of psychological investigations was aimed at demonstrating that the combination of two signals, in one visual field, increases information selection requirements on the HUD (Table 17).

The data presented on Table 17 show that:

- signal perception is affected, depending on the background, ('void' or 'informational'), against which the information is presented, and
- efficiency of the flyer's interaction with the HUD depends on the amount of information presented on the HUD; excessive information exerts a negative influence on the reliability of perception (increased perception time and number of errors). This psychic conformity extends to signal encoding by any physical means.

Table 17. Perception quality of two signals on the HUD.

The criteria of estimation / Experimental conditions	Perception against neutral background		Perception against the background of cues	
	Simple facial part	Complicated facial part	Simple facial part	Complicated facial part
Time of collimator indicator presentation, sec	1.0	3.0	1.5	4.5
Latent time for estimation of indications, sec	1.34	2.07	1.76	2.19
Erroneous estimations, percent	2.1	16.2	5.5	27.9
Missed cues, percent	–	–	6.0	31.1
Number of measurements	360	540	360	540

The obtained data stipulate the engineering and psychological requirements for the limitation of the number of simultaneously displayed parameters on the HUD. The next series of experiments demonstrated that the HUD, during landing approach, maintains the flight bearing path and gliding, but only during manual flight (against the background of visual ground cues). The advantages of the HUD, compared to the head-down instrument panel, became evident in flights with terrain-following trajectories at high-speed and target search reconnaissance. The results obtained in the simulator are shown in Table 18.

The HUD, when the flyer concentrates his visual attention outside the cabin, actually increases efficiency and favourably changes information storage. However, there were difficulties in devising control manoeuvres on the base of the HUD flight parameters.

Additional experiments concerned an accurate understanding of the pilot's inhibitions and their reasons. For this purpose, the flyers were asked to perform more complex missions. For comparison, the same flight tasks were performed using screen and conventional instrumentation. The evaluation of piloting during takeoff for a ground target attack mission, (a manoeuvre demanding high coordination skills of vertical and horizontal flight), has shown that flying with the HUD, the deviations of the flight parameters were greater compared to flying with the electromechanic instrument panel. We observed dangerous changes in speed, banking angles, and vertical velocity.

Tables 19 and 20 show comparative data of the flyer's performance scores using the HUD and the conventional head-down display.

In this experiment we used one of the first experimental HUDs and, we were able to determine the following deficiencies in spatial orientation:

> Bank angle 'inside-out' indicator (the movable line of the horizon), air speed indicator counter and vertical speed moving scale.

Psychological analysis of the flyer's activity, while using the CRT, showed that the problems were related to the specificity of aircraft attitude presentation. We tested the analogue HUD on which the flight parameters are displayed on moving vertical scales and digital counters. Builders of the foreign equipment purposed this mode of flight information presentation on the CRT. In electronic vertical indicator and other CRT display systems, and related information equipment are not presented on primary round scales, but on linear vertical and horizontal scales. Furthermore, the foreign HUDs use digital indices with dimensionally rotating scales, for one and the same parameter from one regime to another, and replacement of indicator parameters on the same scale. These particularities may appear to be useful

Table 18. Flight performance scores at low altitude.

Form of indication	Probability of threatening deviations, in %		Percent of detected targets
	On altitude	On vertical velocity	
Traditional Head-Down display	24	8	74
Collimator (Head-Up) display	7	0	80

Table 19. Comparative evaluation of flight information gathering using head-down and head-up displays.

Mode of flight parameters indication	Number of eye movements between head-down display and out-of-cabin aerial space visual inspection	Total duration of out-of-cabin visual search activity of flyer, %	Duration of eye fixations (sec) at out-of-cabin viewing	Duration of eye fixations (sec) at head-down display viewing
Traditional head-down flight instrument panel	30	54	2.0	1.7
Collimator (HUD) indicator system	8	90	6.7	1.6

Table 20. Probability of efficiency and reliability changes in utilising of head-up and head-down displays (shown in percentages).

The indication system Criteria of estimation	Collimator (HUD) indicator	Traditional Head-Down Display
Break-down of ground target attack	42.2	9.7
Dangerous ground proximity event	37.7	29.0
Complete loss of altitude (ground collision)	24.4	9.7
Loss of aerial velocity	11.1	3.2

Table 21. Comparison of aileron elevator control movement standard deviations (conditioned units), utilising two types of indicator scales.

Axis of control	Type of scale	Flat and Level	Turn	Spiral	Landing
Lateral (ailerons)	immovable	1.5	2.9	1.6	1.8
	moving	2.6	3.1	2.3	3.2
Longitudinal (vertical stabiliser)	immovable	2.3	3.3	3.2	3.1
	moving	4.1	4.0	4.9	4.0

for flight information presentation, but for the human factor research support these technical inventions are rather a psychological hindrance than an advantage. Investigations on flight simulators have revealed that flight information encoding modes in the CRT interfere with earlier acquired sensory and motor skills. We have partially de-automised pilot's skill and excessive workload through their sensory, motor, and cognitive processes. This meant increased operational stress and, apart from increasing the workload and the stress of the pilot, it lowered his performance, changed the structure of his control movements, and the treatment of information.

In Table 21 the data are presented, characterising flyer control activity.

Increased aileron and elevator standard deviations, using moving scales, implies that the pilot has some difficulties to control movements, which is related to flying skill disorders. The spectral analysis of the control movements has indicated that the use of moving scales encourages locomotion and control instability. Moreover, eye fixation on the moving scales, compared to the immovable ones, is approximately 1.5 times greater.

The aforementioned changes of the skill control and the locomotor structure were not observed in the direct command mode steering. This is explained by the fact that the mode of direct information encoding was little changed, due to a high generalisation of the signals. In the given case, the colour and the index sensibility were changed on the CRT. This was the only adaptation needed by the flyer. All other control characteristics were the same on the CRT and on the electromechanical instruments.

The psychological analysis of sensory, motor, and intellectual flying skill components, based on the analysis of the new principles of the flight parameter encoding, made it possible to formulate a proposal to give preference to the fixed scale with a moving index. The experiments revealed also a negative effect of scale changes on the performance of the pilots. This was manifested by changes in the control movements: poor coordination of movements and consequently poor performance.

Psychological analysis of the obtained data showed that by changing the scale size, the pilot was forced to translate one unit into another. Reading time increased by 25 percent, and errors did occur. The decrease of the negative effect is linked to similarity in the exterior appearance of scales (zeros as referenced points, a sign of deviation from them). The preliminary results of our investigations differed from the foreign specifications: first of all, one needs to introduce the principal of the spatial attitude, 'outside-in' or "immovable earth – moving aircraft index", flight information on fixed scales, distribution of sizes and linear scale measurements, and new illumination requirements.

By 1970, these requirements were experimentally validated as a timely provision of flying safety, and we also adopted the CRT. The HUD does enhance the efficiency of information gathering under conditions of combined instrumental and visual information. Optimisation of the updated HUD, linked to the automatisation of flight control and display director in formation instrument landing, improves low altitude flying over terrain with obstacles, aerial target interception, and other precision flight tasks. The modern VSI and HUD are less efficient for manual flight control than

electro-mechanical instruments. This is because the flight parameter indicators on linear scales and counters are worse than the round scales. To atone for the deficiencies of signals, encoding modes may be done by automatising the controls and displaying the direct command signals. The implementation of screen indicators must be realised in parallel to flight automatisation, otherwise the HUD will be used to control the flight parameters during visual flight steering, and the VSI as a spare instrument.

This provoked a strong protest from the builders. Our main fault was to veto the VSI as the main head-down instrument panel. At this time, in the USA they were modifying the spatial attitude indicator with an artificial horizon corresponding to the moving line on the HUD. This unequal struggle with the aviation industry, and the Inspector General of flying safety, sided with the engineers and the designers, and completely ignored the recommendations of the Air Force Institute of Aviation and Space Medicine, and of the flying personnel. Strong supporters of the American spatial attitude indicator were A.A. Manucharov, A.A. Polsky, M.A. Dvornikov, and N.V. Adamovitch. In the meantime, much data had been collected with the HUD aboard. The results, however, were not widely publicised. But, service literature reported that "after the implementation of the HUD and the appearance of computer-generated images, and the need by the flyers to widen the scope of the visual orientation, a considerable number of aviation accidents, related to the system of information display, were reported." (Statler I.S. "Ergonomics of the military pilot", USSR Air Force issue, Moscow, 1988 p. 19). This was discussed at length in our Air Force. Historians may read about these discussions in the Air Force magazine "Aviation and Cosmonautics" ("Aviatsiya i Cosmonautika"), published in 1966 and 1967. For the first time, since 1928, the editorial board of this magazine gave the military flyers a chance to vent their individual views.

The Institute of Aviation and Space Medicine, (1973), has carried out experiments with the new HUD, model IPP-2, where the aircraft roll was presented as 'inside-down' (fixed aircraft symbol – moving artificial horizon). Sixteen flyers were tasked to evaluate the use of the HUD. On the head-down instrument panel we installed the spatial attitude indicator, (PKR-72), with an identical display of the aircraft's roll position ('inside-out'). All subjects, without exception, complained about difficulties in precision steering because of the aircraft spatial attitude display.

Objectively, it was found, that in comparison with the head-down display, flying with the IPP-2 HUD, the lateral control channel was significantly degraded, which was manifested by a much greater range of deviations in maintaining the required bank angles and the increased 'expenditure' of the control stick in a roll axis.

The principal of spatial attitude, and its display, generated a negative reaction; as a rule, the flyers considered them unacceptable, inconvenient and a failure. Their negative feelings were explained by the false presentation of the roll that led to erroneous performance. One of the pilots did express his doubt about the possibilities of such display.

Furthermore, 14 flyers reported difficulties in piloting the aircraft, due to the unusual presentation of the spatial attitude. The 'inside-out' concept of spatial attitude requires changing of the flying skills. The flyers have reported that for the mental image of the aircraft spatial attitude, one needs to concentrate, and before making any move, it must be carefully thought out. The noted difficulties are the indices of the control skill disturbances, whereby its most complicated component is the information treatment. In connection with this, the flyer is justified to object to the IPP-2 mode of spatial attitude presentation. A study has indicated that the "aircraft spatial attitude display was one of the main reasons for poor steering accuracy and frequent loss of spatial orientation". Based upon the results of the conducted experiments, the test pilots and the ergonomists of the mock-up commission for the MiG-29, and Su-27, as well as the evaluation board of the HUD project [SEI-31, System for Unified Flight Parameters Indication "Narcissus"] had proposed to restore the previous spatial attitude display, i.e., 'outside-in'. Since I am continuing to quote the different opinions on the subject, I need to expound the concept of the flight image on which 'outside-in' was originally created.

Flight image is a mental flight image, continuously created by the pilot during flight. It is based on acquired experience of visual flying and all other sources of information. A monograph has been published on the subject, (Image in a system of psychological activity regulation; Obraz v systeme psykhologicheskoy regulatsii deyatelnosti,

Moscow, 1986). However, I should also briefly discuss the 'outside-in' spatial attitude concept. It is mainly important to know who and how one perceives space. Most pilots perceive space [the horizon] motionless. According to data collected by questioning flight instructors by M.A. Kremen, 38 out of 47 claimed that space, including the horizon, is always stationary. All flight instructors teach the cadets this spatial perception during early flight training ("during flying it is necessary to align the aircraft with the horizon; during upside-down flight the space around us does not turn", the flyers write on the forms). The instructor-pilot, V. Mednikov, believes that spatial attitude perception changes according to the subjective estimation of the flyer. Some pilots consider themselves, and their cabin, as the Center reference point around which space is moving. Their flight image coincides with their perception (with the visual scene). According to the author, this image makes flying difficult but, as a rule, this occurs only in the initial stages of flying training. Later, especially in high-performance aircraft, a new image is formed and the earth is motionless. They steer the aircraft with a geocentric coordinate system, and the flight image does not coincide with the visual perception. This flight image is preferred since it facilitates steering the aircraft. It is important to stress that the image of the spatial attitude, and the out-of-cockpit view do not coincide, and that flying is much easier using the geocentric coordinate system.

A study of the statements, expressed by experienced flyers has shown that the pilots distinguished the visible picture and the mental image of the spatial attitude. "As it appears to me", writes pilot N.T. Tenitsky, "the flight image is first of all a psychological idea. It is not the visual scene of the aircraft's position in space". According to his opinion, based on the flight image, the flyer thinks: "It is I who is flying, it is I who controls myself." Pilot S.S. Ivanov depicts the flight image as follows: "If one closes the eyes during visual flight, a flight image emerges, and one senses the spatial attitude of the aircraft in relation to natural cues; in creating this flight image the entire complex of our sensations does participate".

The former USSR decorated pilot, V.I. Tsuvarev, believes that: "The image is not identical to the visual perception of man, but is based on the obvious reflection in his mind. This is an evident symbolic representation about something based on all our senses, and not merely on the visual one". According to another former USSR decorated pilot, P. Bananov: "Not a single pilot thinks for a moment that during aerobatic manoeuvres the earth or the horizon moves". The pilot always sees the horizon as fixed, while the aircraft is constantly moving. The illusion of a leaning horizon may occur but, as demonstrated in practice, only in people not associated with flying activities, or in pilots with poor concentration. The pilot assumes that the illusion is based on the 'inside-out' artificial horizon indicator of the AGI type. This horizon, with the immovable silhouette of the aircraft, has caused a lot of aviation mishaps.

Air Force Major General, former USSR decorated pilot, Candidate of Technical Sciences, G.F. Butenko, and military test pilot, G.G. Skibin, also relate the aircraft spatial attitude display to the flight image inherent to the perception of people living on earth. They are convinced that the 'outside-in' spatial attitude display conforms with human nature, therefore the flyer needs this mode of attitude indicator. The instruments designed on the principal of 'inside-out' do not allow attitude determination without additional mental effort during flying.

For the majority of the flyers, spatial orientation is better realised using the 'outside-in' spatial attitude display, since this is related to the image formed by the flyers during flight training. Hence, it follows that I need to briefly review the main functions of the flying activity image.

The notion of spatial orientation consists in the capability of the flyer to estimate his position relative to the gravitational vector, and to the various cues located on the ground. For the flyer, spatial orientation represents a constant awareness of his attitude and movement of the aircraft in space, relative to the earth surface and out-of-cabin cues, as well as about the condition of the dynamics of individual flight parameters characterising motion in the three-dimensional space. For man, the element of coordinates is the vector of the earth's gravity. During flight, most false spatial attitude sensations, relative to the earth gravity vector, are due to the fact that the direction of the acceleration (when the aircraft enters a bank) is perceived as the direction of the earth's gravity force. Actually this means, that even during upside-down flying, the pilot does not feel his head is down and, although he sees the earth above him, he knows that the earth is beneath him. Therefore, in the man-machine system, spatial orientation involves cognitive transformation of visual information. This means that the flyer's spatial

orientation demands awareness aimed at the constant evaluation of the incoming flow of information. Though spatial orientation is merely a basis for the flying activity, in visual flight, it is implemented, as a rule, without a special conscious control. During instrument flying, the pilot is required to create this basis, aimed at active orientation. This is how the pilots described this process.

I visualise the aircraft's spatial attitude according to the flight instrument indicators. During instrument flight, I have a mental image of the aircraft's spatial attitude. When entering clouds, I remember the spatial attitude of the aircraft based on the horizon, and while banking or pitching I mentally see the attitude of the aircraft.

To visualise the spatial attitude of the aircraft based on the flight instrument indicators, I must concentrate on the mental image. The image can not exceed control of consciousness.

This means that during instrument flight, the pilot, in addition to the already complex flight mission, must also cope with spatial orientation. On the ground, it is not a separate function, but in real flight it is necessary to have a spatial flight image. The principal element of the flight image is an image of the spatial attitude. Its function is orientation in space. For spatial orientation efficiency, the fixed artificial horizon with a moving aircraft is best. During the development process, each human forms an image of space in the geometric coordinate system. This image is better formed than the image corresponding to the out-of-aircraft cabin view. The latter is formed by cadets during early, visual flight training. Moreover, the novice flyer visualises flight as being performed in full visibility of the scene, and in full concurrence with the perceived image. For example, during a bend the ground appears sideways. However, the relation of the student to the subject matter, the image of which is reflected in his mind, consists in the fact that the subject matter remains passive, while the student is active. Because of man's psychic activity, the flight image changes and forms the image of space, based on individual experience and the experience of all mankind.

In 1976, we had come to the final conclusion that it is unreasonable, from the flying safety viewpoint, to change the Soviet mode of spatial attitude display, 'outside-in', to the Western, 'inside-out'. This decision, in favour of our familiar 'outside-in', was dictated not only by difficulties in retraining the flying personnel, but also because our mode of spatial attitude display is widely in use and meets the needs of our flyers. However, despite the hundreds of spatial experiments, including the Moscow civil aviation investigations (Kovalenko P.A., Spatial orientation of pilots, Moscow, 1989 – Prostranstvennaya oriyentirovka pilotov), we managed to introduce 'outside-in' only in the tactical fighters with the support the pilots.

In 1983, a team of scientists and of test pilots created an original command flight instrument, the ICP-81, which successfully passed a battery of comparative tests with the outdated PCP-77. The former was recognised to be the best spatial orientation indicator. Much of the work, contributing to the development of the given spatial attitude indicator, was performed by test pilots V.V. Migunov, I.I. Stogov, S.D. Khraptsov, V.P. Selivanov, G.G. Skibin, aviation equipment scientists Yu.P. Dobrolensky, N.D. Zavalova, V.A. Tuvayev, and V.V. Lapa. At the end of the 1980s, military test pilots developed and proposed original ways of integrating the spatial attitude display. Eleven years have passed, and the instrument is still waiting for its aircraft. Military aviation continues to fly with the outdated spatial attitude display CPP, and the civilian aviation with the even less successful displays, the PCP-76 and the PCP-77.

These expounded facts demonstrate that prevention of aviation mishaps is a difficult and complex task. This problem may be simplified if the training of the flyers, the openness in research, and the recruiting of scientists are done responsibly. The military and the civilian flyers are not too enthusiastic about the electronic displays, especially the control panels with the tens of special tasks they must solve in flight. I personally know how much 'garbage' was removed for these indicators in order to help the flyer to be more independent of constant dangers. This may be helped by another prevention: the enhancement of the flyer's general culture. Culture, in this context, means the need to learn much more about self and the aircraft.

CHAPTER 6

PSYCHOLOGICAL PROBLEMS OF THE PROFESSIONAL TRAINING

1. Conservatism a Dangerous Flying Safety Factor

All schools, including academies (technical and professional) lean toward conservatism. This is not a great flaw, because educational consciousness, as a philosophy of life, promotes the stability of the teaching process. The foundation of knowledge should be solid. The methodological cornerstone of the training process is renewed by updating the new students. However, what concerns the professional training of the flyers, teaching acquires a dynamic character and depends not only on the student, but also on methods which must bring professional results. The professional teaching of flyers consists of two processes: dynamism and conservatism; they frequently contradict each other. Let me illustrate this by examples. The opposition process may be manifested in the simplest way – scheduling learning time by subject matter. Historically, it has been established that the main subjects in aviation are the aircraft and the engine, followed by their dynamics, equipment, weapon systems, etc. Priorities are set accordingly. But, already from the 1970s information, computer technology, automation, control navigational systems, and weapons have taken over more than 80 percent of the aircraft share. However, the training process, the priority planning and the schedules have not changed. As a result, the probability of meeting with danger during flying, and of using the above listed systems, is proportionately depended on the degree of the flyer's familiarity with them.

Dynamism, as a quality of the professional training, helps with the tactic missions and with the complexity of their accomplishment, while conservatism decreases the efficiency and reliability of actions due to poor knowledge. In aviation, all activities are aimed at flying safety, as there are no good reasons for aviation incidences beyond the scope of this activity. The reason being, that the training process is a system of hierarchic command – "from the top to the bottom". Under normal conditions, such a system may work, but during the training for real combat, negative trends arise, as for example, demographic abatement, and technical-operational impediments. This leads to a discrepancy between volume and level of envisioned innovations and real possibilities. The education system begins to fail. As a result, there is a new phenomenon: ageing of programs, of directives, of plans, etc., which is recognised faster "at the bottom" than "at the top". Psychologically, this means that practice represents a great intellectual potential for an initial impetus to reform the content and the method of teaching. This is a sure fact: "at the bottom" people "become wise sooner". However, in real life the activity of clear understanding is often inversely proportional to the introduction of new ideas. Why?

The main socio-normative regulation of flying training, from the 1950s to the 1990s, was a plan for flying personnel preparation that called for solving the tasks in zones of heightened risk or literally: "administer technology in the range of its flying tactical characteristics". In practice, this means that in professional teaching, an increased complexity level is necessary to accomplish the plan. Therefore, under the notion 'plan' one should understand not only the total flying hours for each flyer, as the level of the flying staff preparedness and readiness, whenever a threat to his country emerges. For this reason, threat has stipulated the training level. A psychological paradox consists in the fact that direct danger is absent, but the flyer should be ready to face it. In the flyer's life, this is expressed by the non-juridical attitude: "Why risk without a reason?" This attitude is at the basis of the concept of flying safety. Thus arose the need to raise the level of combat readiness, without aviation incidents, using realistic combat simulation. For this purpose, one needs pilots with the experience of complex flying missions. But we had few experienced flyers pass on the torch to the younger generation, because of early retirements due to 'age limitation'. Table 22 shows statistical data supporting this. These data cover years 1988 to 1990.

The cause is not to be found in the strict aviation medical standards, but the irresponsible conformism of the elite and the changes in the country's political life. One example may be the 'dispersal' of the ex-USSR Air Force in 1961 and in 1962.

In those years the communist rulers sharply reduced aviation operational units and academies, but the demographic 'shock' came from

Table 22. Demographic characteristics of former USSR air force flying personnel rank and age distribution, (percent).

Air Force Major Commands	Age and military rank categories			
	Up to 35 years	Captains, 35 years	Majors, Lt-Colonels, 40 years	Colonels, 45 years
Tactical Air Command	75	2.6	3.8	0
Strategic Air Command	79	2.4	3.5	0
Army Rotary Winged Aviation	74	5.0	1.8	0
Military Airlift Command	74	12.6	4.6	0.2
Air Force Flight Training Command	70 to 75	No Data		

1973 to 1978: more than 40 percent experienced flying staff was discharged, and the flying incident rate increased by 18 to 23 percent. The commanders were forced to simplify the training and the importance of flying safety. On the other hand, the Flying Safety Command, being alert, emphasised that "...oversimplification of combat readiness training, and groundless limitations of flying activity, do not prevent aviation mishaps and, as a rule, lead to professional disqualification and lowering of flying safety standards". (Excerpt from "Concepts for the Prevention of Flying Mishaps", Moscow, 1989). What should the poor Commander do? In my opinion, he needs to apply the principal of undivided authority: the top echelons must work out methods and means to enhance flying safety through danger. This represents the highest of scientific flying safety support when the capabilities of the flyer are not lessened, but enhanced and, the more difficult and complicated the task, the more independent and personal should be he who teaches HOW TO LIVE IN THE SKY.

In aviation, training is a moral asset, since it is the guarantee of life preservation. This truth has been well understood and implemented by such pedagogically oriented flying commanders as V.T. Gripshtock, N. Kryukov, V.K. Andreyev, V.I. Andreyev, M. Dvornikov, P. Kirsanov, G. Dolnikov, V. Reshetkikov, V. Shkanakin, Ye. Shaposhnikov, et al. Man becomes the object of training and education, and must learn about his endurance to the stresses he will meet in his aviation career. Hence, the teacher, under conditions of professional training, must be able to recognise, not only with the help of the Flight Surgeon, but also based on his knowledge and experience, which candidate has "the right stuff". In this connection, I consider it reasonable to expound the results of some scientific investigations about the human endurance to different life events and work activities of aircrews. This material will be history, if not obsolete by the time of this book's publication. The results of the scientific data below, concerning dangerous factors during training, must serve to change the philosophic concepts of aircrew teaching. Otherwise, the level of professionalism will diminish for those who teach, and for those who are taught. Without professionalism aviation becomes mere transportation.

Let us analyse the importance of psychology in aviation training, starting with the data of the years 1980 to 1993. As I mentioned in previous chapters, beginning from the latest aircraft, Gurevitch (MiG), Sukhoi (Su), Tupolev (TU), Antonov (An), Ilyushin (Il), and with the fourth-generation aircraft, the flyer was expected to retain his courage and to sharpen his mental capabilities. This was also the time when three socially dangerous factors emerged in the decision making of flying safety.

First factor – Loss of the leading role by the Air Force Combat Training and Flying Training Commands in establishing the prerequisites for a successful transition of the aircrews to the new aviation technology. It needed to be proven.

The establishment of all flying training innovations, generated by new equipment, was done by high-ranking technology specialists. All their priorities were aimed at the control of conformity to technical orders and teaching schedules. Moreover, they were in constant contact with the Council of Ministers, the State Planning Committee, the Military Industrial Committee, and the Central Committee of the former Soviet Union Communist Party, and the Armed Forces General Staff. Obviously, their opinion was decisive, and the Air Force Combat Training, and the Flying Training Commands were informed, that... "At the very top the aircraft design was approved".

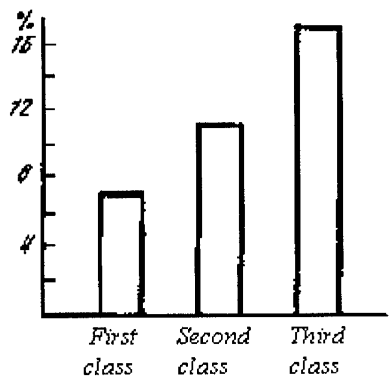
I recall one specific case. A group of responsible scientists and technical specialists argued about which type of rotary-wing aircraft should be mass-produced, the one-seater or the two-seater? The discussion concerned mainly new weapon systems and their control elements and evaluation of earlier unknown tactical capabilities, etc. The comparative testing had just begun. However, the discussion gradually favoured the two-seat helicopter although the one-seat version was better equipped and had better aerodynamic features. Actually, the latest available equipment, such as night vision, remote guidance of weaponry, target selection had been installed on the one-seat helicopter, constructed by S. Mikheyev. Unfortunately, the flight tests did not confirm advantages of on-board weapon equipment, while lack of the helicopter flight control automatisation made its low altitude combat application extremely dangerous. However, striking a balance, the then deputy defence Minister V.M. Shabanov, ended the discussion by saying: "We will produce the one-seat, rotary-wing aircraft, we have already proposed to the Central Committee a new weapon system. There is no way back", (June 1986).

On the OKB (Mil) helicopter, the seats were built to tolerate 4.8 Gs compared to 18 to 30 Gs, as required by the former USSR Air Force specifications. As a result, in the Afghanistan war theatre, 90 percent of the fatal accidents were not in the air, but during a forced landing with a stopped engine (impact acceleration about 20 Gs). The aircrew deaths were caused by head trauma (impact on instrument panel because of poor seat construction). We had an excellent seat in the KM-36, in fact out of 51 flyers who had to eject, 85 percent were safely rescued (in the USAF the rate was 82 percent), although from 1978 to 1982, 38 percent of the ejectees were injured with various degrees of vertebral compression fractures. Impact accelerations with our ejection seats may reach a peak above 20 Gs, while in the USAF they are more stable at around 16 to17 Gs.

During combat, the SU-25 flyers in the Afghan war theatre experienced hypoxia at 6,000 to 7,000 m, (no oxygen used), as well as flying above high mountains with loss of engine thrust during recovery from a dive. There is no need to point the finger at one or another person since all are guilty. The Air Force Combat Training Command was timely informed about these facts, but they were all 'featherweight' for the Kremlin bureaucrats, and were practically ignored. However, we have the support of all the flying personnel. Thus, I believe that most of the responsibility should be attributed to the leaders of the Air Force Combat Training Command.

<u>Second factor</u> – The decrease of the flying professional prestige, has transformed the flyer into an extension of the aircraft whereas, earlier he played a more important role. This was an un-democratic and anti-social approach, which eroded morale and was worse than oil leaking from an aircraft's engine. Thus began a period of cynicism, and the holy service to the fatherland became a sentence to humiliation. Figuratively speaking, the flyer was sought not in the sky, but beyond the tail of the aircraft. The social menace was represented by the fact that conformists and compromisers had been promoted to higher command posts. Moreover, early undermining of the psychic health of the selected personnel may limit a flying career to no more than 10 to 12 years. Demeaning the prestige of the aviation career, imparted an unfavourable demographic trend to the profession. When vacancies existed, 30 to 40 percent of them were filled by professionally unfit 'drop-outs', hoping they still possessed some potential of trainability, and that the flight instructors would try their best to bring them up to the necessary performance level.

<u>Third factor</u> – Poor demographic situation in the country. However, despite many highly motivated people, unfortunately, high motivation is not the same as high intellect. Yet, we needed to establish a new level of flying capabilities. We were not only concerned about the level of mental capabilities, but also about specific traits of the intellect. Intellect, in the flying profession, is the ability of the mind to see and sense upcoming events, which eventually become the key element of a fight mission achievement. Pilot intellect is the capability to see beyond the horizon. The influence



Ordinate – % of errors
Abscissa – the level of class-rated flight qualification (First, Second, Third).

Figure 5. Dependency of flyer's error incidence based on class-rated qualification of pilots.

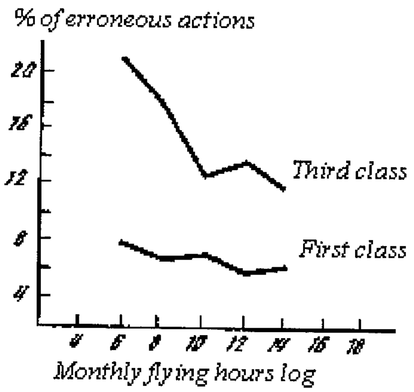
of the third factor increased the number of average flyers. Thus, the number of third class psychological selectees grew, despite the fact that the Air Force Combat Training Command was informed that third-class graduate selectees do commit 2.5 times more errors, as compared with their psychologically first and second rated counterparts. This paradox became a standard: the aviation incidence rate, and level of flyer's disqualification, rose sharply due to the conflict between the psycho-physiological qualities and the flying complexity performance level.

Consequently, the overall characteristics of the flying personnel capabilities, related to the complexity of aviation technology, did not always allow a successful and safe acquisition of the modern equipment, using outdated training manuals. For example, missions involving low flying, landing approach at minimal meteorological condition (80 to 800 m), aerial combat with 8 to 9 Gs for more than 15 seconds, cross-country flights with 3 to 4 mid-air refuelling, etc. Here, it is necessary to add that the adverse demographic situation has also affected the flight instructors, who taught our aviation cadets. Approximately 58 percent of the flight instructors had insufficient training experience (1 to 5 years), more than 40 percent of them were third class flyers (the lowest degree in the Russian Air Force certification). Technology is changed every 5 to 7 years. And just when the Air Force introduces new technology, all the flight instructors may also be changed. Thus, we had the new aviation technology, but a jeopardised flight training.

The above conclusions, although not absolute, do not explain, but objectively characterise role and place of the training process of flying safety. I now will cite some known attitudes, which will illuminate and support my opinion about the three most dangerous social factors for optimal flying performance. In the future we shall use data from the Russian Air Force Institute of Aviation and Space Medicine (N.I. Frolov, P.M. Shalimov, V.A. Varfalomeyev, V.I. Zorile, et al.). Figure 5 Shows the Correlation of Flying Personnel Errors to their Qualification Level.

The comparative data have been obtained with flight missions performed under identical conditions. Viewing the graphic data, you may pose the question – and what is this? It is truism, and we all know that. The training process is intended for the enhancement and the growth of flying aviation professionalism. Yes, that is true, but all is not so simple. The system of flying evaluation, and the type of errors, reflect not so much the flying abilities as the experience. Although this is 'sporty', I see it as a class rating of mastery, as it has been achieved, but not as a criterion of flying abilities.

Figure 6 shows the error rate, per month, of qualified pilots depending on their flight missions. The commanders and schedule planners used this also for layoffs, suspension from flying duties, permission to solo flying. These data were used to establish the average monthly flying workload for the flyers, not less than 10 flying hours, for below this the probability of error rate,

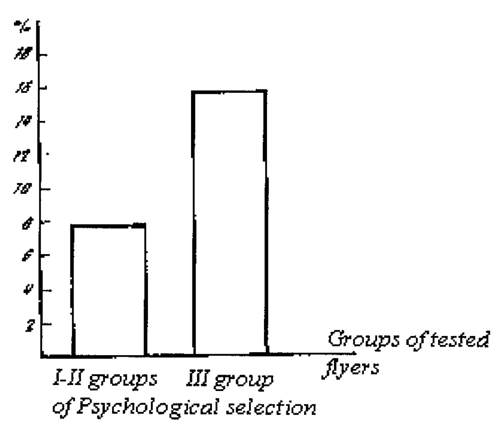


Ordinate – % of errors
Abscissa – monthly flying hours log.
Upper curve – third class pilots.
Lower curve – first-class pilots.

Figure 6. Dependency of flyer's shares incidence on regularity of flying duty accomplishments.

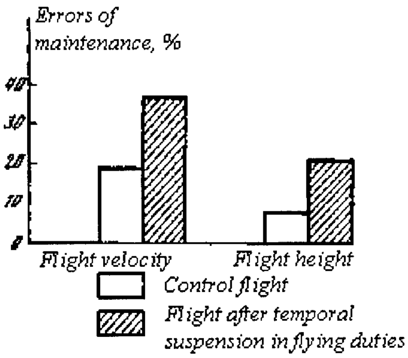
(usually landing approach), became greater. This is not new. I would like to add some psychological comments. Optimal performance is not only due to talent, but also to the personality of the flyer and his self-esteem. The first-class flyer, after a forced rest, is more careful, prudent, and egocentric. The young flyer loses his skills after loss of self-control. He is also egocentric, but tends to be over confident. The egocentricity of the experienced pilot raises his dignity and his responsibility.

The psychological explanations may be differently interpreted, but they are facts, which demand credibility for they are a manifestation of the psyche. Figure 7 shows that a successful training depends not from the level of the developed skills, but from the mental qualities. The explanation of the figure is as follows: the first group consists of the first and second groups of the psychological selection, the second group consists of those whose psychological qualities correspond to the third group of the psychological selection. To understand the results one needs to know that the first-class pilots, and some of the second, were retrained. The flyers of the second group, during retraining to the fourth-generation aircraft, in some cases exceeded the flyers in the first group. I am not trying to estimate the degree of their reliability, but I draw attention to the completely different type of error causes: "incorrect attention



Groups of flyers' scores of psychological selection
(I-II : the best, III: the worst).

Figure 7. Dependency of error rate during transition on Individual-psychological qualities of flyers.



Ordinate – and the air is a maintenance.
Abscissa – the estimated flight parameters

Figure 8. Deterioration of flying performance accuracy after three-week suspension from flying duties.

distribution". This is emotional instability, insufficient capability to forecasting, to making responsible decisions. The flyers making errors in 85 percent of the cases, were also found to have symptoms of emotional vegetative instability. These flyers were inclined to be very upset with their poor performance, which 'erodes' their professional health. In the latter case, flying skills may compensate only to a point. Figure 8 showed the data characterising the decrease in flying performance after a three-week grounding.

Here we are concerned here with the flyers whose psycho-physiological state represents a dangerous factor. This is still an unclear social component. The medico-legal expertise posture, about borderline psycho-physiological disorders in pilots, is concerned only with diagnosis and the medical disqualification. This is throwing the baby out with the bath water. I shall cite one striking example. The most dangerous and complicated missions are usually assigned to top qualified test pilots, who may have some somatic problems, including age-related disorders, since they are usually older than 40 or even 50 years. Thus, the problem of man's reliability in flight would not be reduced to a problem of presbyacusia, whispering speech or a refraction anomaly of 0.3 diopters. Here is a more complicated 'knot' of many 'threads' – health status, flying capabilities, experience, professional longevity, motivation, etc. The integral quality of flying safety is professional longevity. Conservatism, in training, is reflected in the professional longevity. The latter, especially for occupations with high risks, including flying is, first of all, a combat potential. Combat experience of the former USSR Air Force suggests that 60 to 70 percent of combat sorties were performed by experienced combat personnel. The professional longevity is an economic factor, which is especially important under conditions of military reforms. However, currently the mean term of flying longevity for a first-class pilot does not exceed 7 to 8 years.

The most important factor for the professional longevity is the availability of functional reserves and the rate of their expenditure in dependence of age. The level of the functional reserves for flyers, in the 35 to 40 age range, is lowered and quickly exhausted in a yearly cycle. After the age of 30, the work capability of the flying staff has been observed to decrease appreciably, compared to the general population. Scientists have demonstrated that for a 10 percent performance enhancement, the 30 year-old flyer needs to carry out 7 training sessions, while a 45 year-old flyer needs 12 sessions to obtain the same result. Moreover, the maintenance term for the same level performance, in a 45 year-old flyer, is 8 times lower.

Flyers older than 35 have also a lowered adaptation capability for the transition to the new aviation technology, which results in diminished professional reliability, a significant increase of morbidity incidence, and a medical disqualification rate during the fourth-generation aircraft acquisition. However, the majority of senior pilots (older than 30) has been successfully retrained and is flying, which substantiates the necessity and the importance of the systemic efforts aimed at diminishing the influence of factors based on premature biologic ageing.

The hygienic, psychological, physiological studies carried out by scientists of the Institute of Aviation and Space Medicine about work conditions, domestic life, professional training of flying and ground engineering, and technical personnel have established a variety of occupational conditions that are chronic and based on a number of diagnoses related to aviation careers. This trend has been found in all Air Force Major Commands. One-third of the flying staff suffered from one or another disorder, and among ground personnel the diagnoses exceeded 45 percent. A stable trend of decreased flying years due to medical disqualification was also observed. Decreased flying longevity is a direct result of the above mentioned three dangerous factors.

For a better understanding of the problem, a special investigation was carried out to study all social aspects in a wing, which was used as a model. The task consisted in elaborating new approaches to education, upbringing, and training. Organisationally, the team was led by the former USSR Air Force Commander, Chief Marshall A.N. Yefimov, and by the Commander of the Air Force, Lieutenant General Ye.I. Shaposhnikov. The scientific leadership was entrusted to Major General M.C., S.A. Bugrov, and to me. More than 60 scientists and flight surgeons of the Air Force Aviation Medicine Laboratory, and the Rehabilitation Center of the former USSR Naval Aviation took part in the investigation. More than 11,000 observations were carried out, of which 800 in-flight. Flying and ground personnel, families, wives and children of military servicemen, all participated. I will analyse only factual findings. Possibly, my expounding may appear to be saturated with excessive technical reporting, however I am more concerned with the substance than with the style. The difficulty of my task is to demonstrate that, all the above-cited factors are the syndrome of a poorly organised social life, and that the flying safety problem is an 'open wound' on the 'body' of aviation.

2. Medico-psychological Support for Combat Training Efficiency

The dangerous factors of life and of the professional activities were: the state of health, the training, the organisation of work and lifestyle, the ergonomic and the socio-ecological conditions of the flying activities. Powerful, objective, and scientific means allowed to estimate in-flight, and on the ground the dynamics of the psychological and the psychic resources. Firstly, it was necessary to give a meaningful characterisation to the flying work, to evaluate its efficiency, and study the main socio-medical characteristics of the psycho-physiological health in aviators. This was a typical situation in 1986. (The various investigations were performed by V.A. Bodrov, D.V. Gander, O.A. Kosolapov, N.F. Lukyanova, V.P. Sidorov, V.M. Zvonnikov, P.M. Shalimov, N.V. Kravchenko, A.P. Vonarchenko, V.Ye. Potkin, S.M. Melnikov, E.A. Kozlovsky, et al.).

The schedule for flying training was approximately 170 shifts, 2 to 3 times per week, with 1 to 2 flying shifts per day, with an average of one hour and 30 minutes flying time. The total working week consisted of 52 to 54 hours (instead of 41 hours as stipulated by legislation), for the navigators/programmers more than 70 hours. The variations of the work-rest regime, according to objective investigation data, led to cumulative fatigue, even in a single week, in 40 percent of the flying personnel. Moreover, the timing of all activity has demonstrated that prompt planning of professional preparedness had been allowed only 30 percent of the budgeted time.

Ground training consisted of oral briefings of the crews before in-flight combat missions, and written handouts. Simulator training covered only 20 to 25 percent of the time. The standard flights performed in simulators, would have been more efficient in actual sorties. This led to decrease motivation in the flying personnel. Complex missions were not performed. Thus, the analysis of the organisation and methodology of the training allowed to detect a series of dangerous factors threatening flying safety. This caused a lower professional performance level during the weekly and annual shift cycles, and cumulative fatigue which lead to decreased efficiency, as well as to increased error rate. We established that, if missions included combat in the second sortie, the scores were much better, about 4.1 to 4.3, but dropped to around 1.3 in the fourth combat training sortie. Combat was planned in the second sortie only in 29 percent of the flights. By the 8th and 9th months, the combat sorties score was around 3.2. Longer rest periods, between combat flight sorties for more than ten days, led to missed target attacks in about 22 to 50 percent of all cases. The main errors occurred in the target area, and one of its form was a loss of visual contact with the target. The errors were mostly noted at the stages of the most intense time-shared activity. These mistakes were also

registered for the first-class pilots. The professional health of the flying personnel evidenced that, out of 57 pilots, only 74 percent were certified to be healthy and 26 percent had various diagnosis, including spinal column pathology (osteochondrosis), and excessive body weight. In 48 percent we detected a vegeto-vascular disorder. The current health state maintained the required performance level for 5 hours, and work restoration after a 12-hour rest. With the described regime, functional reliability of junior pilots decreased after 4 to 6 months of continuous flying duty, in the experienced group after 6 to 8 months.

The overall level of the physical preparedness of the flying staff was satisfactory. In flyers in the 24 to 32 year group, this level was estimated to be 3.7. The poorest physical preparedness level, 2.8, was observed in pilots suffering from adiposity (over eating). Of the 78 percent of the flyer's lowered tolerance to physical loading, 60 percent had poor speed qualities, and 34 percent an insufficient level of static isometric tolerance of lower body and belly muscles, which, to a considerable extent, predetermine their endurance to high sustained +Gz.

The results of the psychological investigation showed that, in the prevailing majority of the flyers, the psychic status was satisfactory. However, 28 percent of the pilots revealed some deficiencies, which lowered their professional efficiency, and augmented the probability of functional disorders. The most characteristic deviations were a lower level of psychic activity, of intellectual capability, insufficient emotional stability, psychic instability as a result of family conflicts, and insufficiently developed flying skills. In 13 percent of the flyers we noted a decrease in motivation because of the absence of a possible promotion, professional difficulties, conflicting situations on the job and at home. In 17 percent of the flyers we determined a heightened level of anxiety and psychic tension, which was manifested especially by flying commanders, due to their high-level of responsibility and workload, as well as in young pilots because of adaptation difficulties.

It should be stressed that the dynamics of the functional state of the flyers, observed in this study, evidenced marked individual differences, particularly among flyers with poor physical fitness, excessive body weight, poor health, and inferior professional training. Therefore, the results of the evaluations of the professional efficiency and reliability, the state of their health, the physical and psychic status and specific traits of the dynamics of their functional state, during mission accomplishment, have suggested that they are not significantly differed from earlier observed data. Moreover, these data reflect a certain link between the state of functional reliability of the flying personnel, the organisation of the flying activities, and the physical and somatic health status. Considering that the ergonomic and hygienic evaluation of the flyer's workplace, described in previous chapters, it is reasonable to analyse now some socio-psychological aspects of collective life.

As the basis of the socio-physiological studies of an aviation collective is the evaluation of the cohesion level of aircrews, and the psychological microclimate in the families of the flyers. The assessment of the cohesion level did not reveal any significant negative trends. Of greatest interest are the data about the socio-psychological microclimate in the family, as the factor influencing the morale of the flyer. It should be pointed out that this became our priority. The results of anonymous questionnaires, interviews, conversations, etc., have shown that 20 percent of the flyers complained of frequent family quarrels, 50 percent of the flyer's wives were unsatisfied with the intimate relations with their husbands. About 37 percent of the wives were disappointed with the professional activities of their spouses, around 50 percent with the kindergarten facilities and the living conditions, and 20 percent with the slow promotions of their mates. The main causes of family problems were: psychological and sexual disharmony, unsatisfactory social and living conditions, insufficient knowledge (by the wives) of the specific activities of their partners, irrational work schedules, and lack of psychological consultation services. The evaluation of the medical care revealed that the most typical deficiencies were: unsatisfactory training of the Flight Surgeon in the psycho-physiological problems of the aviation profession, low professional status of the physician in the collective, large volume of non-productive red tape work, etc.

On the basis of all the investigations, (much more, then expounded here), carried out with the command staff of the regiment, the Air Force Combat Training Command proposed and approved the following experimental training:

- establish a five-day working week with a two-day weekend – reduce duty time in

non-flying days to seven or to eight hours, and in flying days to eight or nine hours (with a total of 41 duty hours per week);

- fly up to 4 days per week in two shift – reduce the duration of each shift (rotation) to five hours, without an additional rotation pause;
- conduct, in non-flying days, preliminary training according to the timetable of the squadron commander;
- set a timetable for flights, in the squadron, for 2 to 3 flying days per week for each unit, provided that time interval between the next two flying days, for the same flyer, is not less than 12 hours;
- perform physical exercises in non-flying days from 12:00 to 14:00 or 16:00 to 18:00 hours;
- connect simulator training flights on flying days, planning the sessions for 2 to 3 flyers in each squadron, with a total flying hours, per day for one flyer, of 2 hours and 30 minutes, and using emergency situations to activate the psyche of the flyers in accordance with RIASM specialists recommendations (pilot-physician E.A. Kozlovsky);
- implement the methodology of aircrew ground training of visual reconnaissance missions proposed by RIASM researchers O.T. Baluyev, and M.V. Polyakov (the procedure is based on the familiarisation of peculiar small size targets, their recognition against the background of camouflage, and on coordinate computation);
- plan the schedule of flying activity in yearly cycles, take into account the data of the psycho-physiological investigations, send each flyer every 5 to 7 months to rest in a rehabilitation Centre, to recover his professional work capability and to improve the body's functional reliability;
- provide rehabilitation at the USSR Navy Aviation resort centre in Sevastopol, individual nutrition regime for the flying and the ground technical personnel, treatment for personnel suffering from osteochondrosis, neuro-emotional instability, and other disorders.

Thus, the gist of the experimental regime consisted, first of all, of flying duty time enhancement, reduction of pre-flight briefing and post flight debriefing times, better physical and simulator training, improved medical check-ups for psycho-physiological reserves, and provisions for timely recovery from temporarily reduced functional capabilities.

As a result of these corrective measures, we observed a decrease in psycho-physiological stress, improved tolerance to workloads, and reduced recovery times. All this had no adverse effect on the professional activity. In fact, combat efficiency improved by 8 to 12 percent, the number of errors decreased by 22 to 25 percent. Total flying time, per error, increased by 50 percent. Table 23 shows the characteristics of the experimental work-rest regime of the aviation combat training activity, and a psycho-physiological optimisation of flying efficiency.

Apart from the optimisation of the work-rest regime in the improvement of combat training, we carried out a set of medical preventive and rehabilitation measures, including special procedures for support, correction, and restoration of the flyer's functional states (psychic self-control, special physical exercises, individual and group behavioural therapy of family relations, etc.). This allowed to improve self-control of the flying staff by 2.8 times, to stimulate psychic activity by 25 percent, and lower the level of anxiety by 20 percent, as well as to lessen the number of the families with mutually conflicting relations.

Preventive diet measures decreased undesirable changes in the cholesterol metabolism, reduced body weight, and increased physical tolerance. Rehabilitation measures reduced morbidity rate and loss of man-hours, while the sojourn at the resort centre improved the general well being, endurance, and psycho-physiological resources of the flyers by 10 to 20 percent. The reported data show that flying, currently demands more sophisticated work-rest regimes during combat training, more detailed definition of its substance, implementation of new computer-aided teaching systems, etc.

Unfortunately, the full implementation of the proposed recommendations, during the three-year period of this study, turned out to be impossible due to some organisational and technical obstacles. Therefore, we can state, with confidence, only about the proof of the actual possibility of the optimisation of the training process in favour of flying safety.

Table 23. Some results of psychological optimisation of flight combat training.

Optimisation of experimental flying workload-rest regime in aviation regiment's flight combat training organisation	Efficiency of implemented experimental regime
Five-day working week with two-day weekend	Improvement of well-being, enhancement of mood by 200 percent
Duration of total duty service time in non-flying day - 7 to 8 hours, in flying day - 8 to 9 hours	Reduction of flying work psycho-physiological tension
2 to 3 flying days per week with duration 5 hour each day with rest pause between flying duty accomplishment not less than 12 hours	Improvement of flying endurance (on psycho-physiological scores by 10 to 15 percent)
2 hours of mandatory physical training in non-flying days	Increase of efficiency of combat application task accomplishment by 8 to 12 percent
Carrying out of psycho-physiological training. Simulator preparation. Optimisation of nutrition regime and its structural composition.	Lessening of erroneous action numbers during flight mission fulfilment, combat application and operation by 20 to 25 percent, increase of target in-flight detection probability from 0.3 to 0.58
Use of medical and psychological procedures for rehabilitation and recovery of flyer's work capability in postflight period	Reduction of work capability restoration time in postflight period by 1.5 to 2 hours

3. Psycho-physiological Characteristics of the Flying Personnel Activity under Combat Conditions

All aviators remember and know their final assignment: to fulfil the requirements of the combat manual. In the available literature, a lot of data is available describing the peculiarities of the various conditions of man when he performs training and combat tasks. I wish to cite here only some data about the results of the investigations of the physiological state of aviators during "assistance rendering to the government of the Republic of Afghanistan". I will touch only upon the period of active combat operations (second phase, 1980 to 1985). Our military publisher "Voyenizdat" issued, in 1993, the declassified book titled "Losses of the USSR Armed Forces personnel in combat actions and war conflicts".

In this chapter I will report some results of the investigations carried out by IASM specialists at Air Force Bases while deployed in Kaboul, Kunduz, Kandagar, Jelalabad, Bagram (the scientific studies were conducted by V. Bodrov, L. Grimak, V. Zvonnikov, V. Savchnko, A. Strelchenko, I. Alpatov, S. Sytnik, S. Razinkin, et al.). The main thing here is to estimate, from the socio-psychological point of view, the methodology of the training and the aviator's combat readiness. This example, although not the best, emphasises, again, the philosophic postulate about the right to live.

The activity of the flying personnel of the 40th Air Fleet in the Republic of Afghanistan was characterised by a high degree of neuro-emotional stress, a high combat workload, lack of a satisfactory social environment, and sanitary and hygienic conditions of unaccustomed climatic and geographic features. The activity of the flying personnel, under these conditions, uses psycho-energetic resources to a much greater degree than in peacetime. This is conditioned, mainly, by specific combat actions, while the physical and psychic stresses sharply increase and change the performance. These factors predetermined disorders of the functional state of the aircrews, among them chronic fatigue and exhaustion, as well as neuroses. The disorders of the functional state significantly decrease the efficiency of the missions, and even interfere with their accomplishment, promote illnesses, which lead to subsequent medical grounding and disqualification.

From 1983 to 1987 we investigated more than 600 crewmembers (pilots, navigators, weapon systems operators) of helicopter, fighter and military air lift aircraft in the Afghan territory. The investigation was carried out during the training for new assignments in Afghanistan, during service abroad, and upon returning from Afghanistan. The problems to be solved during the investigation were diversified and depended greatly on the working phase, the location of Air Force Bases, and the type of combat activity.

Investigation of procedures relevant to the diagnosis of the functional disorders and the determination of the causes leading to them.

Development of corrective measures targeted at the prevention and treatment of functional disorders.

A study of the peculiarities of the flying personnel functional state was carried out using physiological psychological, and psycho-physiological indices. The method used was based on actual situations, and condition of the flyers during the period of the investigation. Character of combat activities, and their support, required a special activity of all major Air Force Commands, but the most complex and diverse tasks have fallen to a lot of helicopter crews. The predominant part of their missions (aerial tactic fire support of attacking troops, landing operations and deployment of special assignment units, escort of army moving columns, aerial patrolling, chapter-air defence ground nests treatment, etc.) was characterised by close contact with enemy forces. The pronounced neuro-psychic stress, connected with the combat environment, forced aeromedical specialist to give prevailing attention to the helicopter crews.

The helicopter crewmember's, main responsibilities were transportation of combat personnel and cargo, direct combat application and support of ground army troop attacks reaching 450 to 500 flying hours per year (420 to 470 combat sorties). This is greater than 2.5 to 3 times the total flying workload of the aircrews in peacetime. Results of anonymous questionnaires of helicopter crewmembers demonstrated that 90 percent of the helicopter flyers had faced life-threatening situations. The same index among polled tactical fighter-aircraft crewmembers was only 65 percent.

Among the factors influencing aviation personnel performance decrement, as noted by aircrews, were 1) intense flying workload; 2) prolonged takeoff time; 3) nervous tension related to combat situations. The predominate role of these factors was reported by all crewmembers of all investigated Air Force Bases. The helicopter pilots, finding themselves, as a rule, in the fiercest combat activities, named combat stress as the second, and their psycho-emotional as the first factor.

Efficiency of the professional activity, under combat conditions, is mainly determined by the esprit du corps of the aircrews. The latter, being a powerful regulator of behavioural reactions, influences the development of functional disorders, mainly those of psychogenic nature. The results of the anonymous questionnaires suggested that 95 to 100 percent of the helicopter personnel, and 80 to 85 percent of fighter pilots, at the end of their first-year combat activity in the Republic of Afghanistan, had lost their combat motivation. Before departing for Afghanistan, (depending on the level of information and knowledge of the conditions of the upcoming activity and conditions of current flying service in USSR), only 40 to 60 percent of the flyers accepted one year of combat duty. However, lately, their motivation has gradually eroded and, in 5 to 8 percent of all questioned flying personnel, the drop in motivation has been observed, not only for combat missions in the Afghan theatre, but for flying duty activities in general. Motivation for combat duty begins long before departing for Afghanistan. It is shaped by information from various positive and negative sources. Individuals, social, professional, and other problems, also play an important role.

Here is an example: before departing for Afghanistan from Raukhovka Air Force Base, 40 percent of the flying personnel did not know where to settle their families. The flyers arrived at the new station, but housing was unavailable. Families, expecting the new assignment, could not leave their apartments. The nearest housing was in the village of Raukhovka, but there were no houses for lease. The remaining 60 percent of the aircrews had sent their families to their parent's permanent residence. The querying of this group of flyers established that their motivation was less than 14 percent of other groups departing for Afghanistan. As a rule, at the time of their departure for Afghanistan, the pilots already formed their opinion of the upcoming activity. The extreme conditions, aggravated by hard social lifestyle conditions, completed the negative picture.

The negative motivation of the flying personnel coexisted with the understanding of the need to accomplish their military duty. Such ambivalence, alongside other reasons, destroys normal relations, and is a serious premise for the development of psychosomatic disorders. A definite interest for the evaluation of the dynamics of the social re-adaptation is shown by the data related to the satisfaction of one's activity and job position. Approximately 40 percent of the flying personnel considered their activity as satisfactory. Later, during re-adaptation to peaceful conditions, their self-esteem is gradually raised and, after six months, 8 percent of those quizzed considered themselves more mature and experienced pilots. In evaluating their status, (family, service, and health), they noted changes in their relationships. Thus, during the stay in Afghanistan, only 12 percent of the flyers were relatively comfortable. After returning home, the number of satisfied aircrews sharply increased to 63 percent, but in the subsequent six months it dropped to 56.6 percent. Facing actual difficulties, the desire to be 'understood', as well as the indifference of the superiors, to prolonged exposures to stressful combat situations, contributed to a wave of neuroses. The wish to go back to combat duty, after two months at home, was expressed by 18 percent, while a half-year later by 38 percent. To better elucidate the reasons of the negative attitude, I shall cite my talk with Lieutenant Colonel V. Krasnov, on March 18, 1987.

"In 1984 the aircraft Su-25T were in the Transcarpathian Military Region; and of the 52 assigned men, 22 were third class rated pilots, no Commander and no Chief of Staff. The airstrip was poorly equipped. No one had been preparing us to special duties, including the Flight Surgeon. No one to train us about specific flight operations. Those who feared combat missions had been disqualified and grounded for medical reasons. We accomplished 6 to 8 combat sorties a day. The working day was 18 to 20 hours. From October 1986 to March 1987, the Regiment accomplished approximately 26,000 sorties, and lost seven aircraft. At that time, the 'dushmans' were well armed and supplied. Our flyers were yesterday's Air Force cadets. The aircraft were poorly protected from 'surface-to-air' rockets, the thermal sensors were not effective, especially against hand-held American SAM 'Stingers'. Our potential losses could be significant. The attitude, at which aircraft might evade the 'Stinger', is about 4000 meters, however, the boresight at our aircraft works only below 2000 meters. But the 'dushmans' forced us to work at 6000 meters, in unpressurised cockpits, trying to avoid the 'Stingers', and to bomb from 4000 meters. The flyers were censured, the commanders reported that the flyers are timid and fear the rockets, and are flying only in one direction. After three months in Afghanistan, one discovers who is who. In winter it is very cold, but our fur trousers were taken from us. The flyers feared the Flight Surgeons, and would often treat themselves illegally. All have but one thought – to survive. All live on snacks. Ground technical officers and servicemen eat without dishes. On the 10th month one feels like a squeezed lemon. The experienced pilots fly 5 times more than the unskilled. One of our pilots, after ejecting, landed in enemy territory and exploded himself with a grenade. Incidentally, we had survival training at the Chirchik Air Force Base, near Tashkent, the climate was hot and we flew very little. The Su-25T, in itself, is not a bad aircraft, but it has no pressurised cockpit, no oxygen equipment, lacks auto pilot, etc. My opinion is that we should have withdrawn our Armed Forces. The population did not support us. They live in the 15th century. Why are we fighting here? The mood is despondent. We feel forgotten and unneeded. The evaluation of our activities is not objective. The Army commanders deprive us of the flying rations and constantly remind us that the ground troops are fighting and we are only flying. We are killed by the tens, and the ground forces by the hundreds."

I have no moral right to evaluate the above statement, but as a physician-psychologist I am entitled to say that Lieutenant Colonel V. Krasnov was quite fit, and sound of mind.

Obviously, there were also positive examples. In one of the Air Force Bases, a special shooting range was built to train assault pilots flying the Su-25T. The training was aimed at combat action in the Afghan War Theatre. After arriving in Afghanistan, the flyers had additional reconnaissance training, recognition of combat targets, and tactical striking. Gradually, an objective control of combat efficiency was established for each pilot. The Commander, personally, taught the pilots skills of survivability, military ploys, and professionalism. As a result, each highly trained flyer accomplished 200 to 400 combat sorties, and during a three-year combat activity the unit did not lose a single flyer. Thus, the required military training of fighter pilots was established.

Let us, now, view the results of the psycho-physiological investigations of the active military, aviation personnel. A set of complex factors influenced the end of the Afghanistan war. Approximately 68.2 percent of the helicopter flyers had complained of combat fatigue symptoms leading to the deterioration of their performance. An increased irritability and diverse sleep disorders were noted in 39.4 percent of flyers. In 11.8 percent of the flyers frequent bursts of anger were reported, and 14.7 percent of them considered themselves as being on the edge of a nervous breakdown. By the 10th or 11th month of combat activity, 11.8 percent of the flyers evidenced marked psychic disorders, which were manifested by repeated apathy and indifference to mission performance.

The main causes influencing disorders, (in order of importance), were: excessive workload, nervous tension associated with combat situations, prolonged takeoff time, concern for the 'buddies' during combat operations, especially when an aircraft was shot down over enemy territory. Amid aircrew navigators, (from helicopter pilot navigator to pilot navigator of regiment), the main causal factors are: insufficient rest time between missions, prolonged starting time, excessive workload, precision requirements of air-to-ground weaponry. Of all these factors leading to fatigue, the least significant are the prolonged periods between missions, and the conflict between command and colleagues.

The disorders of the functional state of the aircrew were not only based on complaints, and interviews, but also on objective data received with questionnaires. The psychic changes were confirmed by the Russian adapted a modified Minnesota Multiphasic Inventory Test (RAM – MMPI). The profile of the flyer's personality was found to be typical for those troubled by their isolation, and experiencing social adaptation problems to the surrounding reality. This led to the development of persistent negative emotions, conspicuous anxiety, and emotional tension. Apart from this, the flyers showed a greater level of frankness in describing their inner feelings. They asked for understanding and empathy. These crewmembers presented a high degree of aggressiveness in combat, and a definite contempt for communal, moral, and ethic norms.

Pronounced neuro-psychic disorders in flyers, according to the RAM-MPPI tests, were found to be 44.1 percent, while the other 55.9 percent did not present any signs of psychological personality disorders. Alongside with the personality trait changes of aircrew members in Afghanistan, the situational anxiety increased by 28 to 35 percent, as did the level of emotional reactions suggesting a diminished emotional stability. Scientists of IASM, Professor L. Grimak, candidates V. Zvonikov, and A. Strelchenko, have developed prognostication methods to determine who can not handle extreme situations. This allowed, with an accuracy of up 75 to 80 percent, to identify persons most predisposed to manifest a neurotic symptomatology, when exposed to a complex of unfavourable factors.

Prophylactics and rehabilitation measures were developed based on the functional disorders reported by combat personnel. For the prevention of neuro-psychic disorders, psychic self-regulation (PSR) was adopted. This procedure was used with a group of pilots (helicopter Mi-8MT). The sessions were carried out, in the preliminary phase, in a special centre. The total duration of the training sessions lasted two weeks (sessions being conducted once every two days). Comparison of the results of the psycho-physiological investigation of this group of flyers, after one year in Afghanistan, with the results of the control group, has evidenced significantly improved scores of the functional state of the flyers treated with the psychic self-regulation procedure. Along with this prophylactic procedure, we also tested the flyers who suffered from exhaustion. By combining rational psychotherapy, with the self-regulation method, we obtained optimal results. The combination of treatments enabled us to normalise the functional state of the flyers, without suspensions from combat duties, and administration of drugs.

A study of the re-adaptational phase demonstrated, that two months after returning home, the flyers still had residual signs of neuroses – sleep disorders (20 to 25 percent), elevated irritability (more than 70 percent), fatigue (20 percent). More than one-third experienced conflicts with relatives, service and family connected. In 10 percent of the cases, the flyers complained about changed service attitudes, and poor recognition for combat achievements. All the symptoms were manifested especially during the first and the second month, and after returning home.

The study of the re-adaptational period resulted in the establishment of special rehabilitation measures for the flying personnel returning from

Afghanistan. The IASM developed resort facilities to improve the efficiency of diagnostic and treatment capabilities, where methods of psychic self-regulation, and biofeedback self-training, were used. This approach blocked the neurotic symptomatology in 12 to 14 days of treatment, and completely restored the functional capabilities in 18 to 24 days in 92 percent of the flyers (the total number of observed flyers was 186). The used procedures were: autogenic training, hypnotic suggestion, as well as when fully awake, rational psychotherapy, programmable self-regulation using psychotherapeutic means, as electric current induced sleep (A.V. Shakula, O.E. Chernov).

The quoted data are not all consistent since some studies were performed under combat conditions. Fighter aircraft and helicopters have undergone substantial modifications, weaponry optimisation, etc. But all this happened later. And now, as I am writing these lines in 1994, although there is a different political climate, flight training still leaves much to be desired. Evading the tenet of possible cooperation, parity, armament reduction, we need to admit, that the flyer cannot be relaxed, and have to give up a highly qualified professional. Certainly, he does not want to be 'cannon fodder'. Unfortunately, he is at risk to become flesh and bone fragments even in peacetime. I am concluding this chapter by reviewing the most cynic factor threatening the life of aircrews, and may Almighty God save us all in the foreseeable future. There are still about 20,000 military pilots in the Russian Air Force.

4. Will a Drop of Blood be More Expensive than a Drop of Fuel?

Based on data prepared by V.V. Lapa, P.M. Shalimov, S.G. Melnik, V.I. Dudin, V.I. Zorile et al.

With today's socio-political and economic situation in our country, influencing the reduction and the reorganisation of the Armed Forces, the professional training of flyers has been reduced due to a significant slashing in flying activity. This unfortunate trend has been growing recently. As evidenced by the data of the professional training, the yearly total flying time for all the Air Force Commands has sharply decreased by 30 to 80 percent. In 1992 and 1993, compared to 1991, the average total flying time for one major aviation accident dropped to 1,200 flying hours, in 1992, for the first time in many years, the number of major aviation mishaps is beyond the number of aviation incidents. Evidently, one of the causes of the unfavourable changes in aviation accident statistics was the decrease of the total flying time and the irregularity of the flights.

Professional preparedness of pilots to fly missions represents a complex systemic quality, comprising three main components: flying skills, knowledge, and readiness (fitness) of the body to work under specific flight conditions of adverse environmental factors (acceleration, pressure changes, noise, vibration, etc.), as well as psychological readiness.

Flying skills, being the basis of professional mastery, are an aggregate of complex sensory, cognitive, and locomotor actions. They involve:

1) skills of spatial orientation during motion in a 3-dimensional space, while exposed to extraterrestrial factors as velocity, altitude, and G forces;
2) skills of sensory and motor coordination based on the proprioceptive signals received from the control stick amplitudes and acceleration perception;
3) skills of visual depth perception (estimation of the distance from the aircraft to the ground, of space between aircraft [wingman] in a formation flight;
4) sensation of time, etc.

The main cause of automation loss, or even loss of skills, is due to suspension from flying duties. The general rule is that the more complicated the skill, the longer to acquire it, and quicker to lose it. The most complicated skills are spatial orientation and time-shared activity, i.e., aircraft steering and simultaneous use of weapon systems, navigation (during landing approach), mid-air refuelling, etc.

The simultaneous performance of two tasks requires a high automation skill, since attention and awareness of the flyer are stressed to the limit. Automation loss of any one skill, because of insufficient training due to flying layoffs, needs to be addressed, since it tells on the flying mission efficiency, and on flying safety. Investigations have established that a 30-day suspension, from flying duty, causes a significant drop in the flying skills of experienced pilots, (landing approach and instrument flying). A longer layoff, up to 75 days, critically lowers flying efficiency and reliability by 2 to 2.5 times. Even after a short rest from flying duty (approximately 2 to 3 weeks) the number of

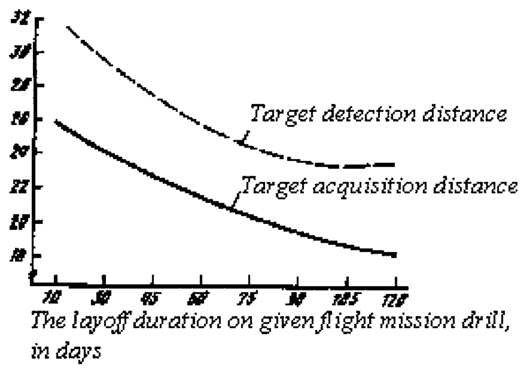


Figure 9. Dependency of aerial target distance detection and acquisition on layoff duration in flights for the given type of flying drill.

errors increases more than twofold (Figure 9), significantly dropping the scores of flying efficiency (Figure 10).

Our studies have shown that, to maintain the flying skills of an experienced pilot at an optimal level, he needs to perform, as a minimum, 11 to 16 flight missions per month, and rest, between flights, not more than 2 to 4 days. If a decrease in mission intensity occurs, the skills begin to diminish and the error rate climbs.

According to the data of Professor N.I. Frolov and his co-workers, the duration of admissible layoffs significantly depends on the level of the flyer's preparedness. For example, it has been determined that for young pilots, first and second year of service, rest periods should not exceed five days. Longer layoffs from duty (more than 6 to 7 days) result in lower combat efficiency by 34 percent, more error by 35 percent, and a deterioration of stress endurance, by the third or fourth sortie, by 50 percent.

A substantial influence on the flying skills is exerted by the flying workload. Both, low and high workloads, negatively affect flying skills. Furthermore, decreased flying times exercise an unfavourable influence on the reliability of flyer's performance, even with comparatively short pauses in flight activities. The uppermost efficiency of the flying step performance, is found with monthly flying time of not less than 10 to 15 hours. Therefore, decreased flying time, or a rest from flying duties, shows a regular deleterious effect on the whole complex of flying skills. Mostly affected are highly organised, complex skills but, first of all, the skills of combat, and landing with minimum weather.

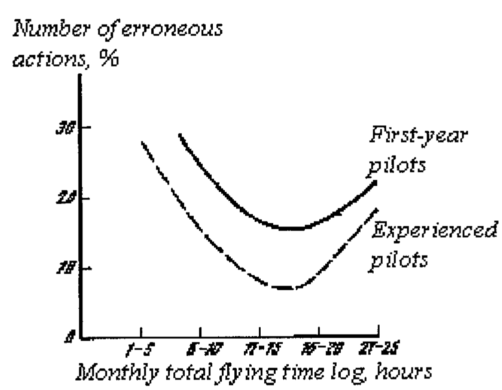


Figure 10. Dependency of flyer errors for monthly total flying time. Solid line - flyers of first year training, broken line – experienced flyers.

The second component of the professional preparedness of the flyer is the adaptation (fitness) of his body to flight conditions. The carried out investigations have demonstrated that the fitness of the body to flight conditions, (optimal preparedness for the diversified phases of functional tensions), demands much greater time and training than the formation of the flying skills, and its decrease occurs earlier than that of the flying skills. For example, even the first and second class-rate pilots, with a great total number of flying hours, after one-month rest showed a marked (38 percent) drop in the quality of flight performance, in their automated skills, and developed fatigue. Rest periods were accompanied by abrupt neuro-emotional stress in flight, especially in young and transitional training pilots.

We also obtained data supporting the need of systematic flights to maintain the professional capability of the flyer at the required level. Rest of 15 days decreases work performance by 45 percent, of 30 days by 57 percent, and of 45 days by 66 percent. It should be emphasised that the adaptation to flight conditions is not achieved on simulators. The only way to conserve the flyer's professional readiness is a regular performance of actual missions.

The third component, of the flyer's professional preparedness, is psychological readiness – the learned psychic patterns which, alongside with other flying skills, uphold the love to fly, takeoff (combat) excitement, self-confidence about the readiness to successfully fulfil a emission. Cutting back on regular flights decreases the flyer's confidence, as he wonders about his impaired readiness. It goes without saying, that this develops a sensation of diffidence, anxiety, apprehension, and fear, which dampens the psycho-physiological resources, and leads to poor performance. I would like to point out again, that the flyer learns to surmount all obstacles because of his love of flying. The motivation, for his unusual love of flying, is the realisation of his helpfulness and indispensability to others. Hence, emotional vulnerability, social sensitivity to society's ratings of his flying profession. Just for that reason, when the flyers are suspended from flying duties, when the aviation cadets, after graduation, are not needed, when the new aircraft are destroyed for scrap, while the old continue to fly, it becomes unbearable and excruciatingly painful. This pain is manifested in a loss of motivation to keep on flying, and this is a national loss, because one of the most skilful and devoted professional populations is overcome by moral apathy and spiritual depression. What is the matter? Unfortunately, something sacred has been lost – the flyer's sense of self-worthiness as a persona in society. How does the flyer feel when he is made to fly only 10 to 12 hours per quarter? This means that his life, which he selflessly and enthusiastically dedicates to the people, is fully disregarded by society, or more exactly, by his superiors. This social phenomenon is illustrated in Figure 11.

In a pilot's life there's no simple mission, because even each takeoff and landing entails nervous tension. However, currently our pilots and cadets, in the academy, are flying very little due to fuel

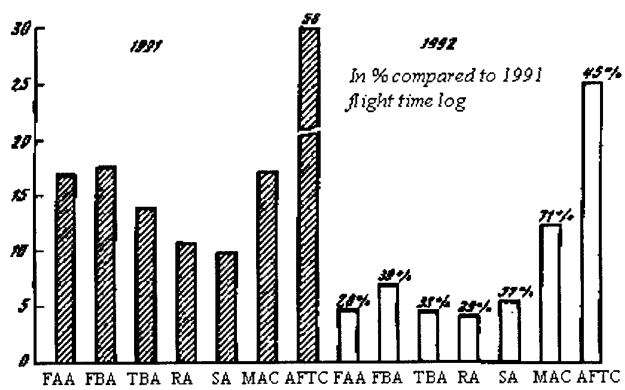


Figure 11. Total flying time per Major Air Force Command, Feb. 1991-March 1992.

shortages. All this generates the real situation for a high rate of aviation mishaps, with a subsequent potential explosion of social aggressiveness by the military personnel and their families. Note: in all aviation mishaps, which occurred in the first semester of 1992, 90 percent were major aviation accidents due to the loss of the level of professional preparedness. In the past 20 years, of every 10 mishaps recorded, (military and commercial), only 25 to 35 percent were major aviation accidents. It is necessary to point out the leading dangerous socio-physiological factors, which man faces in the sky. These factors endanger the lives of aircrews and passengers:

1. Psychological.

Loss of flying motivation in 40 to 60 percent of personnel leads to flying phobias. This may lead to decreased situational awareness and drive to achieve high professional mastery. In some flying personnel, moral apathy, spiritual 'ambivalence', as a rule, are caused by diminished pride in military service. Unwarranted commercialisation as a tool for survival – because of this we might have a surge of major aviation mishaps with civilian and military transport aircraft. Moreover, this will create inter-unit conflicts, weaken family ties, weaker moral responsibility, conscience conflicts about whom to protect based on duty and honour.

2. Professional.

Reduction of flying time, forced simplification in training, prolonged rests between missions, decreased operational reliability of aviation technology maintenance, and too many young flyers. In the given case, these are the causes of aviation mishaps of the last twenty years. Earlier they were more sporadic, now they are regular events.

Note: Reliability of the military flyer, as a professional, is achieved with solo flying of not less than 100-200 hours, and with the total of 160 to 180 hours per year. In 1992, flying time per flyer was 20 to 40 hours. During summer manoeuvres, rest periods must not exceed 7 to 12 days. In 1991 there were approximately 20 major aviation accidents. The flyers did have enough time to use the ejection seat, but they did not…

3. Social.

Loss of flying profession prestige. The competition at Air Force Flying Academies has dropped from 12 to 15, to 1 to 3 candidates per vacancy. The indifference of society and the government officials to the professional, academic, and moral dedication of aviators is the cause of the lamentable state of the aviation training. In 1992, specialised training schools graduated students highly motivated to become aviators, but only one-third of them enrolled at an Air Force Flying Academy.

Note: In the USA, flyers enjoy the highest reputation. During my visit to the USA, I was amazed by a large poster I saw on the road leading to one Air Force Base in Texas: "Here flies the USAF Wing The Blue Eagles. America, be at ease. The Eagles will defend you anywhere on the Globe. Commander of the Wing is Gen…". It is a well-known fact that professional USAF pilots earn approximately $7,000/month, and receive bonuses for risky missions. I am not emphasising the material rewards, but the high esteem for their role in the national security.

4. Medical.

Lowered professional health level. More than one-third of all flying personnel have a diagnosis by the age of 30, and after 40, two-thirds, evidence of a decrease in psycho-physiological liability. More than half of the flying population is incapable to restore the required performance level following a rest period. This is especially true after 8 to 9 months of continuous flying duties, because of unsatisfactory life and psychological conditions that should support flying readiness. More than 40 percent of the families are against social environments, which create a negative attitude toward flying.

5. Ergonomics.

Due to sharply reduced funding, we were unable to acquire new computer-aided systems for the professional selection, for the diagnosis of the healthy men health reserves, for audio-visual systems for psychological support, for psycho-physiological technical teaching of safety measures against extreme flight factors. We had to stop

installing on-board, bio-medical electronic equipment to provide information on the condition of the aircrews. In the USA, the aircraft industry is advancing in all areas, including in air traffic control, in flying safety, in training, and in medico-physiological support.

Note: Abroad, human factors, and flying safety hold the priority of the research and development implementation, (70 to 80 percent), while in our country it is barely 15 to 25 percent. The time of implementation, from concept to application, abroad is 2 to 3 years, and in our country from 7 to 9 years, up to infinity.

It is desirable to legislate social and pension provisions for healthy military pilots who retire early. It is necessary to legislate, (not by departmental orders), the scientifically validated total flying time standards, which guaranty the permissible level of flying risk, and assure a reliable defence of the Russian skies.

Based on the intra-departmental decisions to prevent an outbreak of aviation mishaps as itemised above, the psychological reasoning is presented below.

First of all, it is necessary to allow operational units and Air Force Academies, full flying time, i.e., to give priority to actual flights, and thereby do support the motivation of the flying personnel. As for the experienced personnel, temporarily suspended from flying duties, to arrange the possibility to fly on ultralights. Moreover, to organise intellectual, professional work developing algorithms and mathematical programs for computer-aided training of combat tasks of high complexity and manoeuvring, handling of non-standard situations, solve tactical and operational problems, etc. Namely, to set a foundation of behavioural experiences, and mental skills of newly created systems on a basis of artificial intelligence. In other words, to establish a bank for all the flying experience collected over the years. It is time to evaluate the mind, if the body does not conform.

Man in the Sky should not feel alienated from his beloved activity. To restrict flying duties of test pilots, to those of commercial pilots, will allow them to carry out only their main professional assignments. Recently we have finished a scientific study of the first group of graduates from the Yeyisk Air Force Special Preparatory School. I am deeply pleased to report that the teaching staff of the school coped successfully with the academic program, and 95 percent of all students expressed their wish to enter Air Force Academies. The Sky calls. I was deeply moved when I saw an 80 year-old Air Force veteran, with tears of happiness in his eyes, singing along a song from a children's cartoon.... "I wish, I wish to fly".

If we all, military, servicemen, aviators, civilian government officials faithfully accept in our soul the spiritual imperative – the safety of the pilot ordered to fly is the best way to obey the Commandment: "Thou shall not kill", then we will bring democratic reforms to our country. I want to believe that when my book reaches the readers, that what I have written in this paragraph will not have lost its urgency.

An analysis of the flight training experience of the Air Forces of the USA, of France, of the United Kingdom, of Germany, of Canada, and of Sweden suggests that combat ready aircrews average a monthly flying time in the range of 20 to 50 hours, depending on the target combat task training.

Considering the objective data, concerning the quantitative dependency of the efficiency and reliability of the pilot, (total flying and regularity of flights), we should presently recognise the indisputable advantage of the professional preparedness of the military NATO pilots, compared to Russia's Air Force training. In this regard, it is intolerable, even criminal, at any level, to ignore the facts.

CHAPTER 7

HEALTH, SAFETY, PERSPECTIVES

1. Health Problems in Aerospace Medicine

A comparative analysis of the aviator's medical support by scientific research has revealed a deficiency: the absence of a unified methodological platform. The results of many theoretic scrutinies are neither applied in practice nor are they for the benefit of health preservation, as for the substantiation of negative expert decisions (veloergonomic test).

In this connection, one needs:

- to reinforce interdisciplinary links (psychophysiology – hygiene – information – ergonomics), which will enable to consider health as an integral quality in the system "health – work – capability – reliability", "health – work capability – efficiency". This will enable one to determine health as an object of not only the medical, but of all other departments which support education, training, creation and operations of man-machine systems;
- to provide the practice of medical and health experts with information technology. Computer technology application covers not only treatment and presentation of data, but also the development of software data banks, expert consultation systems on a base of a virtually artificial intelligence, educational games, and lastly, prognostication models for the conservation of professional health at the medical and technical levels;
- to establish automated control systems for the psycho-physiological state of man in flight, according to the environment, mission complexity, and informational changes depending on the dynamics of the psycho-physiological state, etc.

All this imparts to aerospace medicine health conservation a new quality of a restorative medicine. It is not a simple means of treatment, but of control mechanisms using compensatory properties through a specific defence, beginning with bio-blockers, with direct control of psychic processes and conditions.

Our future is in creating principally new vital psycho-physiological defence systems against professional stressors, as well as in diminishing physical and psychological interference during the solution of targeted tasks via education.

New horizons require from the aviation physicians, pedagogues, and scientists a philosophic understanding of the new orientation in aerospace medicine to determine the symptoms of the aircrew. The medical expertise is mainly oriented toward methods of "health – disease" system regulation. The new electronic diagnostic systems may not be utilised for prognostication and preventive measures, but for a stricter 'attrition', which will inevitably conflict with the social striving of aviators and cosmonauts.

To start, let us analyse the present state of the problem. I also wish to note that the health of a population is considered as an index of the nation – factor directly influencing work productivity and the economy. Health indices are also viewed as ecological characteristics of scientific and technical progress. Such a complex approach is reflected in the 'health' notion given by the World Health Organisation, as a state of full physical, spiritual, and social welfare. According to scientific data, the health level is determined by: lifestyle (50-52 percent), genetic factors (18-20 percent), treatment (7-10 percent). Therefore, health is not so much the result of treatment as a reasonable socio-hygienic style of life and corresponding work conditions.

In today's social productive life of various professional groups, the leading causes of the cardiovascular diseases are overweight, lack of physical activity, and psychic stress. Regretfully, the cardiovascular morbidity in the aviation community increased from 11 percent in 1939 to 52 percent in 1984. The main reason: exposure to psychic and physical stressors. The scientists have found lipid metabolic disorders, unusually high hormonal, enzymatic, and immunological conditions, which ultimately lead to medical disqualification of flying personnel due to cardiovascular diseases (approximately 30 percent).

At the same time, the scientific and technical progress has caused earlier unknown job-related conditions, such as informational and intellectual stresses, allergenic environmental problems, primitive work operations, and other factors. Specialists' attention has been drawn to the 'bio-social' nature of man and the ecological balance.

What is the general state of the professional health in aviation?

To some extent, it may be estimated as good, however a closer analysis of the problem has shown unsolved problems, as a reduction of professional life span, a growing number of pilots allowed to fly with partial health loss, and an increasing share of medically disqualified crewmembers.

What demands have been added to the pilot's health by the new aviation technology and the new work environment?

First of all, it should be noted that flying modern aircraft, the sole innate abilities of the flyer do not compensate extreme factors. During flight, there is a constant incongruity between information from the gravity receptors and the actual gravitational axis of man's space attitude. This leads to a distorted perception of familiar objects and of the position of the horizon. It is this dichotomy which produces different kinds of spatial disorientation. I wish to stress that it is the disregard for the psycho-physiological functional limitations in an unusual environment which leads to inefficient technical information under these conditions. And the result is – loss of health or life.

Moreover, flying is a dangerous profession, which involves constant psycho-physiological stress and evokes balance disorders between consciousness and subconsciousness of the central nervous system of healthy pilots. This is manifested by a sub-threshold sensation of weak, but significant signals, as well as by an increased sensitivity of neural signals of uncontrollable state of anxiety, fear, decreased sexual potency, etc. In flight, the probability of important signals demanding a reaction in 0.06-0.1 seconds with a high probability of dramatic sequelae for admitted error, the body releases amounts of enzymes, epinephrine, and glucose, which, under normal conditions, are produced in 5-7 days. Therefore stresses in the professional activity of the life cycle of aviators, in addition to be ecological stresses, is also the "psychological factor of complexity". This "factor of complexity" is present when psycho-physiological conditions of man and the level of his professional preparedness do not provide the required level of performance, and present a direct danger to his health. The analysis of our investigations evidenced, as a consequence of this 'factor', that the initial psychological state would not be restored for the next sortie in 40-50 percent of the observed pilots.

The labour conditions began to tell on the health and on the professional longevity of the crews. On the average, they did not exceed 38 years, furthermore, in the older age group (36-40 years) we observed an increased medical disqualification rate from 16 percent to 32 percent (1992). We noticed a consistent trend in the increase of psychoneurotic disorders, of micro-traumatic injuries of vertebrae, loss of motivation as a disqualifying factor, and job-related spinal column disorders (2 percent). The most significant fact was decreased flying longevity in high-class professionals down to 10-12 years. From the standpoint of high reliability, the loss of this age group translates into a diminished transfer of life experience and professional skills to younger flyers. It may be said, without any exaggeration, that this may equal the extinction of the genetic code in the flying population.

Currently, one-third of the pilot population presents a so-called partial health deficiency. Since the organism does cope with its illness, the pilot is considered to be healthy and fit for duty. However, among these individuals operating the latest aviation technology, we have found an increased percent of pilots with diminished work capability when compared to a completely healthy population. Some of these pilots had been losing flying motivation, had increased family conflicts, deteriorating psychological crew compatibility, eroded spiritual personality, and vital activity. An analysis of this behaviour evidenced lowered tolerance to constantly acting stresses on their personality and organism.

Here are some results of the analysis of aviation mishap cause-effect relationships determined by the state of health of the aircrew. In dangerous situations these pilots are 1.8 times more likely to commit errors, 2.7 times more likely of crashing the aircraft. They also experience three times more frequently psychic disorders, and express self-dissatisfaction five times more often. This is a so-called 'behavioural matrix' of psychosomatic nosology (A.G. Fedoruk, S.A. Kosolapov).

The investigations performed by researchers of the Aviation and Space Medicine Institute of the Russian Air Force have revealed the basic biological levels of man's health. In particular, a correlation was established between metabolic and regulatory disorders in 44 percent of aircrews with abnormal psychoneurologic profiles, and a hormonal imbalance, in 18 percent with kidney stones and osteochondrosis, marked dystrophic changes in 37 percent, suffering from coronary heart disease, and atherogenic alterations of lipid metabolism. Thus, professional dangers against a background of insufficient psychological, hygienic, and social protection are not only risk factors, but also impairing and harmful agents of the organism and systemic levels (I.P. Bobrovnitsky, S.I. Sytnik, V.Ye. Potkin, A.A. Maryanovsky, et al.). In this connection, preservation of aircrew health has a special meaning for the flight surgeon. In my opinion, the most critical aspect of the professional health conservation is insufficient focusing of all aeromedical centres on problems of the hygienic evaluation of the habitat environment and flying work scheduling.

For many decades, the cliché of aviation medicine has been the grounding of flying personnel with the timely prevention of professional sickness – the lion's share of the physician's prophylactic flying safety work centres on pre-flight clinical checks. The scales of this activity may be rated on a base of such figures. The flight surgeon performs yearly from 4000 to 7000 clinical pre-flight checks; the total number of yearly grounded personnel is about 5000, of which, 3000-3500 for deliberate concealment of illness; approximately 1000 due to pre-flight rest regimen violation; 400-500 due to alcohol abuse on the eve of a mission. (A.A. Kupriyanov, I.I. Vvilov, et al.). These impressive figures reflect not so much the qualification of the flight surgeon as the absence of aircrew cultural life. The constant effort of the flight surgeon in the struggle to prevent aviation accidents, has long been the problem of aircrew health preservation. However, as I see it, this is not related to aviation medicine only, but also to the processes of a flyer's health certification of flying work limitations. The focus of the flight surgeon and leading officials must be on HEALTH as such, outside reliability in the efficiency of the man-machine system. Professional dangers of physical, biological, chemical, and psychic nature do decrease the reliability of the whole 'man-aircraft' system. Thus, professional dangers are constantly influencing, prolonged factors decreasing the reliability of aviation specialist (V.I. Belkin, I.B. Ushakov, V.S. Tikhonchuk, et al.).

The new aircraft will substantially change the work process and the conditions in which it will be realised. I will cite some examples. Currently, there is a trend to "raise the ceiling" in the cockpit of some aircraft which may increase the risk of decompression sickness in prolonged flights. The practice of aviation medicine will be facing new requirements for long flights, (10-hour non-stop and even longer missions on fighter aircraft without full physiological provisions for food in water, as well as physiological waste disposal). Special helmet mounted display systems will increase stress on the cervical spine during flight manoeuvres. The physicians will encounter a new phenomenon: prolonged (40-50 seconds, instead of 10-15 seconds) high +Gz with onset rates of 3-5 Gs/sec instead of the previous 0.01-1.0 Gs/sec during combat manoeuvres. Aircraft enhancement, (greater engine power, improved radar detection capability, vectored thrust, etc.) will raise the risk of pilots body damage, of spatial disorientation due to variable +/-Gz in the absence of a normal horizon.

Hence, it follows that medical support must be centred on prevention. It is no secret that the current practice of aviation medicine expertise is aimed at diagnosis. But today we need to reorient our activity to pre-pathology diagnosis by estimating the body's functional state and its adaptation capabilities when clear signs of sickness are still absent. In our case, focusing the flight surgeon's prophylactic activity on prenosologic diagnosis is simultaneously a means to focus on the physiological and the hygienic states of the habitat environmental conditions. A diagnosis of lowered reserve capabilities of the organism will enable us to regulate and influence the inter-relations between man and technology, i.e., to guarantee health conservation. This is directed especially to the flight surgeons, the flight commanders, and government officials concerned with the flying longevity problem.

Today, the professional longevity of the military flyer is in the range of 15-17 years, while that of civil aviation pilots is 20-23 years. A closer study has shown a decrease of 30-40 percent in the 38-45 year age group compared to the 28-35 age group. This presents a social dilemma – aviation safety needs first-class professionals. This is achieved by experience, however, experience

means age. But in reality, the loss of health is directly related to flying work. What is the solution?

Work that conserves professional health should start at the design stage of the aircraft. Ergonomic support of the human factor at the time of conception is a social task, meaningful social programs. Currently, the investigations of the Russian Institute of Aviation and Space Medicine have developed new computer technology for the automated design of aircraft, taking into consideration the psycho-physiological capabilities of man. Thus, enhancement of ergonomics and of work conditions is the first direction of the support of professional longevity.

The second direction is medical. Currently, the leading strategy of the medical support of flying safety is grounding ill crew members, timely disqualification, and thereby prevention of professional disease. Unfortunately, we much too often 'ground' or 'suspend', rather than 'prevent'. So little by little, aviation medicine expertise has begun to prevail over the concept of health without arguing in favour of professional longevity.

There is urgent need to change the radical and the social approaches of health conservation. We must not stress "transition from healthy to sick", but the health resources. It is necessary to check man's psycho-physiological state, the reserves of his functional capabilities to professional stress, his ability to restore vital energy, and his immunological and hormonal resources. Attention should be focused on the factors which decrease the psycho-physiological reserves to the means of controlling these reserves, and to rehabilitation medicine. Without diminishing the importance of clinical medicine, it is still necessary to raise a new flag of restoration medicine for the rehabilitation of temporary work capability and motivation loss. For this purpose, it is extremely important to improve the psychological relationship between the pilot and the flight surgeon. It is time to face the truth. Every year, a few thousand flyers, who are sick or in a weakened functional state, try to carry out their missions. On the average, 30-50 percent of the aircrews conceal the spatial attitude illusions in flight, the feeling of alienation at high altitudes, the excessive reaction to dangers, anxiety, lack of confidence, and sometimes of fear. It is not a paradox but a fact that concealment is due to high motivation, and thus the fear of being grounded, to receive a diagnosis, delay training, is to be suspected of inferiority or cowardice. Possibly, it is time to add to the flight surgeon's white coat the status of church vestments, since the flyer needs are not so much of expertise, as of trusting and believing in him. I believe that most of the listed 'ailments' should not be treated in a hospital but in the sky. But to accomplish this, we need a new theoretical concept. The concept of professional health, which is a property of the organism to maintain given compensatory and defence mechanisms, assuring work capability under all conditions encountered during professional activity.

The systemic quality of the flyer's professional health is the restoration of the functional state in relation to the volume and kind of occupational duties. Let us view the positive changes in the organisation of the medical support we might expect in the case of the professional health concept for the flight surgeon. The given concept provides the shift from an empirical to a scientific position, and allows for the change of flight duty standards based on clinical indications, to enrich and to add the prognostic process in accordance with flight mission tasks. Their approach will require methods and procedures of testing, and the correction of the functional state, the development of control methods for the restoration of altered work conditions. In other words, the medical control acquires a new direction when the functional state, not only the diagnosis, is correlated by the physician with the complexity of the task to be performed. Maintenance and restoration of performance is an important function of the flight surgeon. The notion of professional health, in contrast to the accepted definition of health, means availability of such quality, as the ability of the organism to recover in accordance with the workload standards. We are greatly concerned with all the aspects of the flying safety support, not only with the clinical. Hygienic conditions, as health risk factors, are also of considerable importance, as they become causes of lowered reliability. Therefore, everything that endangers professional health represents an immediate threat to flying safety.

The concept about professional health, as a risk factor for flying safety, will significantly help the comprehension for an individualised approach to plan flight workload, and work out measures for the restoration of functional, physical, and psychic conditions. Thus, it will be possible to move away from a general statement of health conservation to an improved definition – restoration of work capability for a successful flying day. Naturally,

this stimulates the development of new procedures for the diagnosis of fatigue, psychic disorders, nervous exhaustion, and other frequently occurring conditions. An evaluation of the psycho-physiological readiness of man, to carry out a successful mission, will elevate the role of the flight surgeon and make him (her) a full participant in the decision of the accomplishment of a WinGs mission. This should improve the development of psychosomatic, socio-physiologic, and professional training means directed at the restoration of professional health.

For aviation medicine, this concept stimulates a number of new scientific studies. First of all, it is necessary to further develop the physiological adaptation theory with consideration to be immunologic and evolutionary regulatory mechanisms in the interaction of the organism with the aggressive environment. Only with the help of such fundamental investigations will it be possible to elaborate validated principles of hygienic standardisation, dialectically accounting the concept of admissible risk on the basis of medical and biologic priority indicators over economical reasons.

For the organisation of preventive medicine the concept 'professional health' envisages the creation of a complex program of health management and preservation. It should start from the classification of professional dangers and the determination of their relation to epidemiology of professional diseases. From this will follow new medical proposals to industry and management of social measures for the enhancement in conservation of health based on the advance in aviation technology and the complexity of tasks to be solved. Results of the professional health support program will further serve as a basis for medico-technical requirements for work conditions; namely, the purposeful activation of sense organs, intellect, emotions, memory, and satisfaction with social needs. It seems to me, that this program should resuscitate and deepen the scientific investigations in the establishment of links between partial insufficiency, health, and professional reliability.

Special attention should be drawn to the re-orientation of flight surgeons to crewmember's diagnoses. They do not need more medical, but social and psychological assistance. Pilots with diagnoses, have a lower tolerance to increased workloads and to some flying factors. However they are still professionals. They need individualised attention, mainly from their commander. In 1990 the scientists of the former Soviet Union Institute of Aviation and Space Medicine developed computer technology for the diagnosis of health levels, and instruments for the flight surgeon's operative medical control of psycho-physiological reserves (A.S. Kuzmin, N.V. Soloshenko, Yu.A. Kukushkin, V.G. Doroshev, et al.). These devices will allow one to estimate the difference between pathologic and decreased functional conditions. The flyers with a lowered functional state will learn procedures of health restoration. The experience gained observing the flying staff with diagnoses suggests that approximately one-third of them have insufficient physical and psychic endurance up to intense psychic stress. Scientific data suggests that after nine months absence from flying a marked fatigue does develop.

The results of the scientific studies at RIASM on the effects of flight factors on the health-state of aircrews allowed the following objective conclusions:

The conditions of the flying work are characterised by a variety of purely professional dangers leading to pathology, and premature loss of professional qualification, long before retirement age. Hence, the need to create diagnostic centres (clinics) for rehabilitation medicine. Here, the flyers can recover their functional state via psychological support, sport exercises and games, biofeedback, etc. The use of simulators, along with psychotherapy, allowed to return to active duty many crewmembers who had lost faith in their capability to perform their flight duties (A.G. Fedoruk, A. Kupriyanov). At the Central Military Scientific Research Hospital of the Russian Air Force, the implementation of new diagnostic technologies and the use of psychotherapeutic procedures and sports allowed the return to flying duty of 30 percent of the flyers with a full medical disqualification (A.I. Ivanchikov, A.V. Kucherenko).

The third direction of the flying longevity is training and motivation reinforcement. Evaluation of the medical expertise suggests that some of the pathology, of the vegetative and nervous systems, develop as a result of a psychological personality conflict between loss of motivation and love of flying. This phenomenon has clinical roots: spiritual exhaustion due to inability to perform more complex flying missions. This is, first of all, the dereliction of an individualised approach, of

non-validated deregulation of a work-rest schedule, mistrust, over-cautiousness, oversimplification in flight training, lack of promotion prospect, prevailing formalism over genuine support of the mastery acquisition, and situational behaviour in aviation accident investigations. Hence, it becomes understandable that in the 1990s more than 80 percent of medically disqualified flyers were not motivated, while in the 1960s they were only 7-10 percent. The loss of flying motivation undermines the professional health in the flyers, which undermines their flying mastery.

From all this, it follows that the fourth direction of the flying longevity is the provision of socio-psychological conditions of the professional activity and, first of all, the support of psychological readiness to danger and reliability in non-standard situations. It is the lack of preparedness to complicated conditions, to solve problems in a time-deficit situation; and handling information which leads to distress and feeling of inferiority. (V.G. Kostritsa, A.V. Belinsky). The profession demands vital activity to overcome the unfriendly environment. If we do not collect these inner forces, we will not conserve flying longevity. Therefore, we should create, develop, and reinforced the main interest of the flyer's life – to fly, happily, and with confidence. Oversimplification, over-standardisation, over-limitation are a direct threat to the professional longevity and to health.

Thus, maintenance of professional longevity touches all aviators, because the span of their career is our highest civic virtue, a measure of the spirituality of the aviation brotherhood. In the given situation it means: if the flyer has lost his health by his own fault, it is acceptable, but if because of the poor conditions of his flying work, it is asocial – for it is our fault as we did not try to live our life to be a role model.

2. Professional Health of Aircrews is a Requirement for Readiness to Work in Extraordinary Situations

Starting in the 1990s, aircrews of military in civilian aviation started to be used in zones of mass casualty emergencies, as well as in local military conflicts, to assist the victims of natural or industrial disasters, war-ravaged refugees, injured and traumatize people. Under such conditions, of all the risk factors threatening flying safety, the leading one is organization of work. Fatigue, sleep deprivation, irregular flying hours, all may become more deadly than a missile or a rocket. This can cause personnel losses, predominantly to violations of flying safety requirements, rather than to combat losses. In the given case, health and its reserve is the best defense. In the arsenal of flying safety, one should have reserves such as psycho-physiological training, operative procedures for work capability enhancement in flight, psychopharmacological support, and other means. As an example, we will review the role of aviation medicine in support of military flyer's activities.

If we consider aviation medicine as a branch of military science, assuring combat readiness of the flying personnel, then it is characterised, first of all, by a fundamental all-embracing quality, and more precisely, by the quality of integration with sciences, which provide weapon systems in training. A designation of aviation medicine consists of rapid and aggressive implementation of knowledge about man's capabilities to perform efficiently in an extreme environment. It would appear that mandatory participation of military personnel in a rapid deployment of forces should be a stimulus for the development of new forms of efficiency and of safety support. However, at the time this book was written, little was accomplished, except for some individual items: construction of bullet-proof vests for flyers, portable emergency surgeon rescue kits, procedures for psychological and pharmacological support of aircrews (G.P. Stupakov, S.I. Sytnik, G.B. Bogoslovov, et al.). Taking all this into consideration, the proposed theory of professional health may promote the role of aviation medicine to support rapid deployment of forces. In particular, the theory determines the direction of practical scientific proposals for the development of new principles of protective means, life support systems, survival and rescue systems, new biologic and biophysical equipment, original training, and teaching devices. Moreover, aviation medicine influences the creation of computer expertise and of consultation diagnostic systems for the prognostication and the control of the psychological and the physiological conditions of man.

Health 'reserve' is a potential of high combat proficiency. Such an approach will change, at least in Russian military community, deeply rooted views of aviation medicine as a 'subsidiary' instrument in the implementation of large-scale war operations. With this approach, aviation medicine becomes a system-generating factor

unifying all systems, which support the human factor by controlling health and work capability.

Thus, the proposed theoretical concept of professional health, as a basis of combat capability and readiness of troops, is simultaneously a social program of man's protection, as it is aimed at the maximum conservation of his prolong activity. In most military jobs (flyer, sailor, tank officer, commander or Ranger etc.) health, as a factor of professionalism, might be considered as a causal factor of greater risk in achieving tactical and psychological superiority over the enemy. In the Great Patriotic War, 1941-1945, out of every 1000 downed aircraft, 700 were hit by Ace flyers. In Afghanistan 60-70 percent flight of the missions were performed by experienced aircrews.

At the same time, modern practice is such that only 10 percent of the high-rated professionals (age group 35-45 year) fully conserve their professional health. Science should disclose the cause of negative manifestations and means to eliminate them. Consequently, it seems reasonable to review the results of the scientific investigations of the human factor, entailing health, work capability, reliability, efficiency, motivation, and state of combat spirit. I will cite only some factors confirming mainly the productivity of the professional health concept.

The environment of military technology influences both, health and combat readiness of military personnel. The specialists in aerospace medicine from the RIASM (E.V. Lapayev, V.I. Belkin, Yu.V. Krylov, G.D. Glod, I.N. Cherniakov) have carried out investigations which evidenced a relationship between reliability of human actions and the degree of increased risk factors over hygienic norms. It was established that work conditions, when using military technology, decrease the reliability and the efficiency of the "man-military technology" system, and may unfavourably influence the accomplishment of a military operation.

We have obtained data indicating a relationship between complexity level of performance and the degree of diminished human psycho-physiological reserves (V.A. Popov, B.M. Pikovsky, P.K. Isakov etc.). Additional investigations of biologic and physiological reactions of a healthy organisms of metabolic and immunologic processes to harmful military work factors allowed us to determine a relationship between metabolic and regulatory disorders. It should be noted, that repeated exposure to acceleration of 5-9 Gs in MiG-29 and Su-27 aircraft releases catecholamines and adrenaline, which affects blood clotting. In this, in turn, it is a risk factor of cardiac ischemia (P.K. Kyselyov, G.A. Fedulova, et al.). Studies performed by I.M. Alpatov, L.G. Dratch, A.G. Fedoruk, and O.A. Kosolapov have revealed a connection between health level and man's professional reliability. Their results suggest that a large number of aviation accidents occur with flyers having one or another partial health problem.

Pilot reliability is influenced, to a significant degree, by man's psychological state, especially by the professional qualities related to his military job position. According to D.I. Shpachenko's and B.L. Pokrovsky's data, the flyers in the third group of the psychological selection were grounded 3 to 4 times more often for medical reasons, and were involved in as many times in flying incidents. From the military viewpoint, they are potentially unreliable and present a risk factor for aborting a flight mission. All this was confirmed in the Afghanistan war-theatre. The investigations by RIASM specialists have revealed some significant factors corroborating the described concept.

The activity of the flying personnel in a mountainous and desert terrain (Afghanistan) was determined by three main factors: flying workload, specific combat situations, climate and geography factors. Combat workload was mainly determined by time and character of performed operations, though the number of combat sorties grew from year to year. If the 1980s flying personnel had performed 49,823 combat sorties per year, in 1987 their number rose to 249,482, whereby the aircrews flew approximately 6-8 hours per shift, with an average starting time of up to 12 hours. The average number of combat sorties per day for fighter, ground attack, fighter bomber, and reconnaissance aircraft was 3 to 5, and military air lift and rotary aircraft 4 to 6 and 6 to 9, respectively. In a few cases the flight crews had to perform up to 15, and even more combat sorties. Average yearly total flying time exceeded the level on former USSR territory (peacetime conditions) by 3 to 4 times, and by more than 600 flying hours (A.D. Sergakov).

From the standpoint of the psycho-emotional effects on the flying personnel, the conditions in Afghanistan presented a unique situation. The analysis of modern military conflicts (North Korea, Vietnam, Middle East) has evidenced that the main threat factor for the flyers, of both sides, emerged,

as a rule, in the phase of actual combat. However, in Afghanistan with the heightened air defence activity of the enemy against flying targets, (stationery and mobile flak-systems, portable flak-missiles systems as the 'Stinger' and the 'Blowpipe'), the factor of mortal danger was constantly present, especially at and near the airport. In fact, the greatest number of hits was on takeoff, landing approach, and landing. This necessitated a radical restructuring of combat tactics. I am drawing special attention to this, as a striking example of professional health relationship to the aviation tactics. Poor health, in this case, became a real danger factor of flying safety, and a direct danger for the aircrew to become a 'non-combat loss'.

Starting in 1986, the altitude for helicopters was 4000-6000 meters for military cargo aircraft 6500-8000 meters, ground attack aircraft (Su-25) 6000-10,000 meters, however, since the cockpits are not pressurised, the flyers were exposed to hypoxic hypoxia. But the mentioned altitudes are averages, as in reality they might have been greater, since this was the only way to evade a hit by a 'Stinger' missile. A sojourn in an unsealed cabin, at an altitude of more than 4500 meters, would be of 1-2 hours, and even longer. Therefore, approximately 40 percent of the flyers, especially during the first two to three months in Afghanistan, noticed the unfavourable effects of high altitude hypoxia, including loss of consciousness, strong headaches accompanied, in some cases, by vomitus. The on-board oxygen equipment was not utilised, while on the helicopters it was dismantled due to lack of medically certified oxygen.

I wish to note the incredibly low-level of safety in the AM-12 transport aircraft without pressurisation. These transport aircraft average 6100-6700 m altitude during flights of up to 1.5 or more hours of duration. It should be stressed here, that these aircraft had no on-board oxygen for potential administration. In fact, from December 1981 to July 1986, three military passengers died and two pilots were medically disqualification due to severe hypoxia.

The high altitude factor was also extremely significant for aircrews of the fighters SU-25, which were also not pressurised and not intended to operate at altitudes of more than 7000 m. Consequently, at altitudes of 7000-10,000 m, even when some oxygen equipment was used, decompression sickness symptomatology did occur. It varied from paresthesia to bends and even retrosternal pain. After descent, these symptoms disappeared, but some crewmembers complained of residual decompression malaise on the ground. The main cause of the above described phenomena was violation of pre-flight denitrogenation (not less than 30 minutes before sortie), which was practically never done, especially in summer when cabin temperature often exceeded 60 degrees C.

A definite influence of the functional state and work compatibility of aircrews was demonstrated by the manoeuvring in mountainous terrain, where the possibilities for detection and recognition of targets were extremely difficult due to a short trajectory path, little time for target acquisition, and highly complex conditions of recovery from ground attacks (I.M. Alpatov). Moreover, a geographic region, plagued by frequent dust storms and haze, interfered with takeoff and landing, with target search and reconnaissance, and negatively affect engine performance and special weapon systems. These conditions significantly deterred mission strategies, when combat efficiency demands exceeded flying safety standards.

The climatic conditions in Afghanistan were highlighted by high summer temperatures (up to 54-56 degrees C in the shade), dry air, sharp changes from relatively comfortable fall-winter season to extremely high temperatures in spring-summer months. The same was noted by significant (up to 15-20 degrees C and higher) daily temperature differences and exposure to dangerous factors (hypoxic hypoxia in highland areas, dust 'blizzards', etc.). The temperature in the cockpit of a parked aircraft, as well as taxiing and climbing, exceeded the external temperature by 10-12 degrees C, and often reached 50-65 degrees C, and higher; considering the heat radiation factor, these values sometimes reached 70 degrees C and higher. The effect of high temperatures, in the airports located at 2500 m above sea level, were often manifested against a background of hypoxic hypoxia, which 'released' intense adaptation mechanisms, especially in the first 2 to 3 months of stay at such locations.

The refusal to recognize aviation medicine as a branch of military discipline, but as an organisation exceeding its help to traumatised and ill personnel, has led to the loss of aircrew health. The proposed recommendations for an optimal adaptation period (preliminary transfer from the base of permanent residence to a base in an arid, hot zone, special thermal adaptation training, administration of adaptation drugs, targeted medical selection, etc.)

were not headed. Furthermore, in some cases, measures were taken which aggravated the already difficult process of adaptation. Moreover, about 20-25 percent of the flying staff was administered gamma-globulin after their arrival to Afghanistan. This did not boost but did lower their immunity and adaptation (S.I. Sytnik). With great difficulties we managed, after four years, to have our recommendations adopted, namely, to transfer airmen to Afghanistan in fall instead of in spring.

Diminished professional health, at the expense of weak reserves, led to an increase of general pathology in the flying staff serving in Afghanistan. And, during their stay in Afghanistan, sick calls were more than double of the units located on USSR territory, (peacetime conditions). A sharp increase (from 1 to 2 and up to 34 percent was noted for nervous disorders, for the cardio-circulatory system (from 3.4 up to 10.6 percent), for the digestive system (from 6.8 up to 51 percent).

An analysis of the medical disqualification of aircrews, for the period from 1981 to 1986, has evidenced that the prevailing disorders were of a psycho-emotional nature (neuroses, ulcers, myocardiopathy). Based on U.S. data, during the Korean conflict, the USAF lost an almost equal amount of servicemen to emotional disorders as to combat.

Efficiency of the professional activity, especially in combat, is determined mostly by the level of one's motivation. This is a powerful regulator of behavioural reactions, due to a prevailing influence on qualitative and quantitative characteristics of man's functional state. Before departing to Afghanistan, the positive motivation for the forthcoming flying duties was 50-70 percent, while after 5 to 6 months of combat it dropped 95 to 100 percent (army helicopter pilots), and 80 to 85 percent in fighter and fighter bomber aircraft. It should be added that 35-38 percent of the flyers experienced a marked fear of flight, and 12-14 percent of them (despite the anonymity of the questionnaires) used any pretext to dodge flying missions (V.M. Zvonnikov, L.P. Grimak).

Probably this caused (based on anonymous questionnaires, data) periodic unsanctioned self-treatments (oral sedative drugs, without seeing the flight surgeon) in 75-80 percent of helicopter flyers and in 55-60 percent flyers of fighter-bomber aircraft. The importance of the psycho-emotional stress factor was also confirmed by the fact that 90-95 percent of the aircrew showed positive values, and considered it necessary to use regularly tranquillising 'cocktails' prepared by the IASM specialists. In order to find out the potential consequences on the health of the Afghan war veterans, the Institute of Aviation and Space Medicine compared the data of clinical and biochemical investigations of 215 helicopter flyers who actively participated in combat operations. The results have suggested that the number of Afghan war veterans with 'a diagnosis' was 3.5 times higher than in non-combat aircrews. In 96 percent of the cases, the diagnosis were established either during combat in Afghanistan or years after returning home. The symptomatology of the diseases suggested a dominant pathology role characterised by excessive psycho-emotional stress. Of the total number of diagnoses, neuro-circulatory dystonia (labile hypertension) was at 41 percent, diseases of the digestive tracks (gastritis, biliary duct complaints etc.) at 32 percent; sequelae of trauma, wounds at 8 percent (A.N. Golovchits, A.D. Sergakov, Ye.S. Berezhnov et al.).

The results of the biochemical investigations evidenced significant changes in metabolic processes. A comparison with similar professionals and same age group flying personnel, not Afghan war veterans, revealed biochemical signs of psycho-emotional disorders. According to R.K. Kyselyov, and I.P Bobrovnitsky, they involve: psycho-emotional stress and hormonal dysrhythmia (2.4 times more than in non-combat flying staff), elevated risk factors of cardio-vascular pathology (4.7 times more frequent than in non-combat flying personnel), increased risk factors of carbohydrate metabolism disorders of the pre-diabetic millitus type (4.5 times higher), immunologic disorders (2.5 times higher). The characteristic fact here was the biologic age. Based on the biochemical condition of the Afghan war veterans, it was, on the average, 6.7 years greater than the chronological age of the non-combat control group (V.S. Tikhonchuk).

Therefore, even in the absence of a full picture of all flyers who participated in the Afghan war conflict, and based on gathered data received from those who continued to fly after returning home (peace time conditions), one may conclude that the environmental combat factors in Afghanistan have produced crucial changes in the metabolism. These changes may be considered, on the one hand, as a manifestation of chronic psycho-emotional combat stress and changed psycho-emotional reaction in

subsequent years, and, on the other, as the result of adaptation to such conditions.

The health problems observed by our specialists indicated the need of implementing a specific rehabilitation course directed at the correction of changed psycho-emotional reactions, and the accompanying metabolic disorders. In the opinion of professor S.I. Sytnik, it is necessary to create a rehabilitation, which would include not only the 'after work' phase, but also the 'current' and even the 'preventive' restoration phases. The latter phase must be subordinate to the solution of problems of increased overall resistance of the human organism, and the optimisation of adaptation processes, including the factors of the psychic trauma effect. This unfortunate experience confirms, once more, the need of a radical re-orientation of aviation medicine to protect the health of aircrews. One of the ways to support combat aircrew readiness maintenance is the establishment of a new prognostication system of the exhaustion and restoration of the flyer's reserves.

Such methodological re-orientation and qualitative restructuring of the entire system of the flying personnel medical checks is impossible without the implementation of automated systems (computer technology). At the Institute of Aviation in Space Medicine, an organisational structure of the medical control was developed consisting of a general data-bank of the aircrew health, an automated system of operative medical checks, and of the expert diagnostic system of the health level evaluation during dynamic observations. The databases include the medical information of the flying personnel health from the very moment of enrolment in the Air Force until retirement (reserve or pension). They are set up with a designation (for example, medico-flight expertise) or based on nosologic classification of diseases or physical deficiencies (S.N. Zagorodnikov, A.A. Kolchin, Yu.A. Kukushkin, et al.). Availability of a wide net of information search and retrieval systems for extensive preventive evaluation of the flying staff health condition will enable the flight surgeon to determine their correlation with the deterioration of the professional activity, to estimate the state of the functional reserves, to verify a diagnosis, to opt for treatment procedures, and to track the efficiency of restorative and rehabilitation measures.

The second component, the automated system of the medical check of the flying personnel, allows one to conduct pre-flight and between flight medical checks of the flyers, and to gather a large volume of data to utilise the files of the received information for extended medical evaluation and standardisation of workloads, accounting of occupational dangers, estimation of work capability and trainability of the flyers (Developed by A.S. Kuzmin, P.M. Shalimov, N.I. Frolov). The medical checks of the flying personnel using an automated system are done by the flight surgeon. He uses a PAV-01 and a portable module complex (PMC), to measure the subjective estimation of pilots health, BP, heart rate, body temperature, sensory motor reaction time, tremor, critical flicker fusion test (CFFT), muscular strength and endurance, etc. These indices are automatically entered in the computer, which handles the data, and estimates the scores of flyer, based on the individual baseline data, as well as the integral evaluation of his condition. All data stored in the database. When needed, the flight surgeon may retrieve these data and analyse, for example, the dynamics of separate indices, certain time intervals, and evaluate the trend of their variations.

An important component of the proposed medical health control will be the diagnostic complex, allowing not only the evaluation of the functional condition, but also to determine the functional reserves of the organism. Tests were carried out in the operational units using this system designed for the prognostication of the psycho-physiological reserves and the dynamics of their expenditure under exposure to flight factors. It encompasses a complex make-up of software and hardware for the registration of the following indices: clinical status, functional tolerance of the organism, psycho-physiological characteristics, professionally significant psychological qualities, complex of software for the treatment of primary information, formation of the integral evaluation and its classification to one of the four levels of the professional health, based on the corresponding databases and knowledge bases.

The results of the tests in the Air Force operational units have demonstrated a high efficiency of the developed system; due in part, to this system we were able to diagnose, every quarter, 22 to 45 percent of the flyers with a professional health level of a "pre-pathologic (pre-clinical) state".

3. The Health of the Healthy Man: Strategy and Tactics

Currently (1994) in Russia a group of scientists headed by Professor A.N. Razumov, has developed a new concept about the health of a healthy man. It is significant that the theory developed in aviation medicine for professional health has laid a foundation of a general concept for the future national health protection system. I think it appropriate to expound my, and A.N. Razumov's, views on the given problem.

In the interest of reducing anxiety in our society, we proposed a rather simple solution. The basic idea consists in assuring the health of the Russian population by stabilising factors for a decent family life, for success, and for a peaceful old age. Good health is a sum of national and individual happiness in life. Health consists of the spiritual needs of each individual and of those related to his country. Currently, around 70 percent of our citizens suffer of some pathology due to environmental pollution. Good health is more economical and productive through prevention than treatment. Today's health is a reserve of strength on the road of Russia's recovery. Presently, we have 20 percent healthy people, but after the realisation of the proposed concept the figure will rise to 80 percent. Good health is the road to prosperity.

Professing the principal of the diversity of options, I shall expound conceptual views on the problem of preventive medicine as a health protective system. Usually, preventive medicine is understood to fight the spreading of diseases, epidemic outbreaks, and traumas, thus promoting longevity and preserving the gene pool. Here, the emphasis is on the prevention that protects the health of the healthy man performing his creative work. The problem, as a conceptual philosophical task, has been upsetting, for a long time, the great minds (statesmen, scientists) who have convincingly proven the relationship of ethiopathogenesis of every disease to life's history, culture, and labour. Some of our famous scientists, I Pavlov, V. Bekhterev, V. Vernadsky, I. Davydovsky, V. Kaznacheyev, F. Meyerson; clinical specialists, Yu. Lisitsyn, A. Sakhno, I. Brekhman, S. Pavlenko, G. Tsaregorodtsev, and socially oriented clinicians and academicians, N. Asosov, N. Bochkov, B. Karvassarsky, I. Kassirsky, N. Blokhin, Ye. Chazov, et al., support the need to develop a special medicine branch about the health of a healthy man.

Physicians, sociologist, and economists have always considered the health of a population as a national well-being index, as a system creating factor uniting such general categories as culture, economics, ecology, education, policy, etc. As for the definition of health, it is left to the experts of the World Health Organisation and to our scientists, V. Kaznacheyev, Yu. Lisitsyn, et al. The importance of these determinations is that the substance of the 'health' term goes far beyond the frames of the medical responsibility, since it concerns the individual or the population as a social unit. Health is a measure of life quality and of state policy. In this connection, national health is the final result of the state policy, creating the possibility for the citizens to consider their health as a permanent asset, as a base for the continuation of healthy generations, a conservation and improvement of the working potential. This is necessary to improve the gene pool, the activity, and the spirituality. However, with all the parameters composing the vector of the national health, in our country, we have not yet achieved the desired results. And this in spite of the fact that in Russia we have more than 500,000 physicians, about 2,000,000 nurses, around 13,000 hospitals and 117 medico-scientific research institutes. Before I explain my strategy and tactics for health preservation, based on the existing politico-economical situation it is necessary I give you a brief overview of the state of health of our population.

The health level in the former USSR was determined (50 percent) by the lifestyle filled with ecological, social, and everyday life discomforts. Workers were not assured 'normal' living conditions and a well-balanced nutrition. Man was rated lower than the product of his work. It was not an accident that poet Rasul Gamzatov wrote "the bread should be a little cheaper, but man should be a little costlier". The health of our labour force was not considered to be important.

It suffices to say that the air in Russia was contaminated yearly by more than 50 million tons of toxic substances from industrial plants and automotive transport vehicles. Maximum levels of the pollution concentration in 94 cities surpassed 10 times the admissible norms. In some regions of Russia the incidence of morbidity due to environmental pollution was 5 to 7 times greater. Due to our lifestyle, and based on our culture, people assumed an indifferent attitude to the administration's violations of sanitary and health standards. As a result, out of more than

100,000 scientifically validate standards for all economic departments, armed forces, and educational facilities, only 30 to 40 percent were applied. Therefore, it is not an accident that we have now, not only a high morbidity and mortality rate, a lower birth rate, but, what is more tragic, a genetic degeneration trend, decreased spiritual geopolitic awareness, intellect, eradication of the Russian population and of their role in the development of the world's civilisation. Those who are still capable to retain their health, started to leave the country by the ten thousands, and at present only 20 percent of our population is healthy.

What is needed by the state to establish a system to protect health? First of all, preserve a healthy generation. On that score, we have been observing a decrease in the birth rate from 17.1 to 12.1 per thousand, and an increase of the death rate from 10.5 to 11.4. In the years 1987-1991 we reached a negative population growth. More than 40 percent of the new-borns have health problems.

The second index is the health of the growing generation. Here are the dynamics: in the first to the eighth grade an increase from 6 to 12 times of visual and hearing problems, 10 times of motor disorders, 15 times of CNS disorders; 75 percent have various health problems, and 84 percent of the armed forces draftees cannot perform basic physical training.

The third index is the health of the work-able population. In Russia, 95 percent of the population is ailing, daily on the average, three million call in sick, 20-25 million on the jobs complain of a pre or post morbid state. More than 70 percent of the population near pension age are suffering from many ailments. It should also be taken into account, that in Russia many retire 5 to 10 years earlier than in the developed countries. Life expectancy for males in Russia is 10 to 14 years less than in the USA, UK and France. All these facts allow the hypothesis that the nosologic principle of the preventive medicine organisation for health conservation is not warranted by the medico-legal expertise, since their main focus is always on disease and the patient. Figuratively speaking, medicine has taken on the sins of others, and left the responsibility of the country's health to others using the weak excuse of the risk factor.

For this reason, we need a new strategy for the theory, the practice, and the organisation of the health preservation of the healthy human. It should be stressed that we are not speaking about the replacement of the established medical preventive practice, but about the foundation of a new medico-social prevention, and preservation of health. The essence of the conceptual re-orientation to the social consciousness, the institutions, and of the state services for the problem of the national health, is the foundation of socio-ethical controls of the healthy man's health protection. Prevention, as a system and a service, means that at the centre of attention should be a healthy mother and a healthy father, a healthy child, a healthy worker, a healthy lifestyle, healthy activity, and old age. A broader understanding is a healthy ETHNIC POPULATION as a source of prosperity of the Russian people in the system of the world's civilisation. And all this relates to the methodology of the healthy man's health protection at work. We are talking about early prevention, not only at the time of the clinical diagnosis, but with a simultaneous prognosis. One does not cure the disease, but one needs to restore the psycho-physiological reserves, which provide a balance between the organism and the environment, the adaptation to stereotype changes, and a response to extreme factors.

This theoretical concept may be realised on one condition – an employer's constitutional and legislative requirement to insure health maintenance through a socially oriented economic policy. Hence, the strategy of health protection is, in essence the management of social prophylaxis. It proceeds from the analysis of Russia's socio-economic reforms, the methodology of inter-systemic links of the scientific disciplines, and the organisation of the health conservation system.

Let us dwell on the above listed basic structures of the protection system of the health of the healthy man.

1. Russian political, economic, and socio-psychological reforms, the constitutional protection and maintenance of health, all envisage a high psycho-physiological activity of man and his freedom to choose a career and a lifestyle warranting a life quality, equalling his energy and intellect. What is new in this statement? The principal difference is the shift of the health responsibility to the individual. Medical insurance has failed to distribute equally the quality of medical services to the patients. Health, common sense, and economic activity are basic attributes of man in a market-driven system. In other words, man's wellbeing depends on his psychophysical

state of mind and efficiency. Strictly speaking, health acquires the quality of a commodity that must be skilfully and parsimoniously managed. Thus, the principal health protection feature in a market economy consists in the fact that the health economic factor has moved from the state monopoly into the hands of the worker. Health, as the economic factor, consists of: a) the preservation of a high efficiency work performance of professionals whose health determines the consistency of the result of their work; and b) preservation of a healthy human gene pool by creating a psychological attitude for health and for socio-economic well-being in a system of competence and survival. This demands radical changes in the philosophical strategy of health preservation principles.

Since worker's health is an agreement between the employee and the employer, the strategy consists in establishing a drive for a healthy life style, as 'comfortable' living, and work-and-rest. This means that, starting from the pre-school education to the training for a speciality, one needs to introduce a new subject – "the social health of the nation" as a component of the cultural education program. It is important, for economic limitation, not to restrict human culture. Need, as an individual characteristic, motivates man to be healthy, while society and its social institutions, in accordance to circumstances, add to health of the following system-targeted functions:

a) maintenance of social-working activity as a biologic force of the society to prevent diseases;
b) organisation of a high cultural lifestyle for the maintenance of health, corresponding to the level of the technical progress; and
c) preservation and transmission of the gene pool through the family institution.

Thus under the new economic conditions of life restructuring, work, learning, and health are not only a body condition, but a subjective self-assessment of the working man. Self-assessment may be considered as a social regulator of man's attitude to work conditions, and the process of work activity. Man, whose desire to be healthy, as a cultural and self-consciousness feature, will require a correspondingly greater remuneration. All of this raises the level of knowledge about health and the procedures for its preservation and of the rules for its protection.

2. Theoretic preservation strategy of the health protection of a healthy man

It concerns, first of all, a physician's philosophic paradigms to prevention changes. Probably, this will demand a certain period of time for accepting new approaches to health restoration and preventive treatment. 'Restorative' medicine, health centres, rehabilitation centres, medical insurance, professional health centres are not concerned much with ill persons, as with the professionals who have temporarily lost the psycho-physiological reserves they need to carry out their occupational duties. Methodology may give different diagnoses: the best results are obtained with tests based on everyday work activity. Expertise differences in 'restorative' medicine are not concerned with limitations, but with the degree of rehabilitation. The emphasis is mainly on the difference in methodology. Preservation and 'reconstitution' of health implies an improvement in the 'communication' between medicine, psychophysiology, psychology, ergonomics, hygiene, information, sociology, and economics through labour laws.

Based on the above, health is not a condition of the organism, but a qualitative status characterising work capability, efficiency, and reliability of the professional's performance. The evaluation of these facts suggests the use of new information technologies as data banks of expertise based on artificial intelligence, and prognostic models for health protection. The multiple health connection to the work process gives rise to the creation of automated health control systems based on environmental parameters, functional state of the organism, psychological complexity level of the problems to be solved, etc. As you can see, the interdisciplinary relations have prompted us to develop better systems to regulate the body's compensatory processes.

It follows then that the concept "health of the healthy human" needs to be changed from the traditional process of health-to-illness to the preservation of health reserves. The tactics are:

a) estimate human functional capabilities to withstand loads under which man performs;
b) estimate the organism's capability to restore its reserves in a predetermined time interval;
c) estimate the availability of biologic material for the restoration of reserves by determining the immunologic, hormonal, in psycho-physiological functional states.

In this case, health protection represents the control of the exhausted psycho-physiological resources and the relation of this process to man, the conditions, and the organisation of his labour. I wish to stress the socially regulating role of the methodology of restorative medicine in the interests of the professional health.

It suffices to say then that our concept of professional health and the informational technology for the determination of the organism's reserves, developed at the Institute of Aviation and Space Medicine, using military aviation technology, has given concrete results. We established the causes of flying longevity reduction, and the standardisation priorities of the risk factors with their damaging effects. We founded and staffed professional health centres and implemented health screening for various professional groups. Using computer technology, work standardisation, and organisation, we improved greatly individual workload, psycho-physiological training, self-control of psychosomatic reserves, and the dynamics of professionally important qualities.

Strategy and tactics to create a protection system for the healthy man's health.

The strategy of the establishment of the health protection system is part of a state policy priority aimed at the interests of all the social strata of the Russian population. It should be understood that it is necessary to give the health protection system a national prestige. The socio-psychological national prestige of a healthy nation consists in the fact that health is a stabilising factor in the confidence of all forms of economic management and economic ownership. Health represents the welfare of an individual, a family, and a professional group. Health is an indicator of the working potential level of the general culture, and the efficiency of the state order.

Tactics validate the option of priority. Selection of the functioning mechanisms of such a system and its classification is no less important. In order to solve the given problem, some principals of the conceptual program should be explained. Prevention consists of preventive, ecological, hygienic, psychological, ergonomic, rehabilitation and diagnostic medicine (A.N. Razumov). Each has its priority and its infrastructure. However, there is a common consent. Let us pay attention to some general priorities. It is our understanding that the key problem for prevention medicine is lowered importance of health, a sharply decreased recognition of health's value as a factor of vitality. Hence, it is necessary to greatly improve, at all levels of the labour and the cultural life of the population, in state, municipal, private, and commercial sectors of the economy the true status of the country's health, the causes of its deterioration, and ways to improve it. We need to mobilise the mass media to help with the task. Together with the state policy, we need to urge the actuation of health data banks, of risk factors, of all health-promoting centres, expositions, competitions, means for individual training, private schools, insurance companies. Our super task is to raise the awareness of the population about its health state, and to establish a socio-physiological attitude for increased mutual responsibility by the employers, and by each individual.

The next priority problem of health protection is counteraction to premature and elevated mortality rate at all ages, including trauma, suicide, and poison. The solution of this problem rests on the estimations of the increased environmental pollution, of the economic welfare level, employment growth, increase of extra-marital birth rate, criminality level, decreased occupational safety and sanitary hygienic standards, as well as child and geriatric care. We include the resources for preventive measures with the health protection laws for the entire population. Simultaneously, it is important to keep in mind, that psychic disorders are long acting in the cause of poor health.

The final, high priority goal, may be the country's working conservation potential – professional longevity. This demands the immediate implementation of the healthy man's health protection concept. The establishment, in the Air Force, of defence industry plants as ergonomics and aerospace technology control units, the construction of health centres, oil and gas industrial facilities, a government health Center in Moscow, and some state and commercial institutions; may all serve as an example of a successful solution (G.M. Zarakovsky, A.N. Razumov, I.S. Nikitin, V.I. Vigdorchik).

What brought about (constituted) success?

First, scientifically verified standards assuring health protection laws were established. Technical and teaching premises for primary and refresher training of staff authorised to supervise the enforcement of the laws were also established.

Second, creation of an inter-departmental program of health protection to support the informational, the ergonomic, the diagnostic, the health promoting, the rehabilitation, and the treatment centres.

As a result, it was possible to support, to a degree, the ergonomic work conditions, the psychophysical health of the working man, his high work capability, psychological activity, readiness to surmount complex situations, motivation for the highest performance, and to decrease the accident rate. These are some views on the foundation of health conservation utilising the "healthy man's health" concept.

In conclusion: I shall once more emphasise that the national idea, "health of the healthy man", originates from a concept of the professional health as a process of a scientific concept of the aviator's life and work (1983-1993). This process is the work of the intellect in the soul of well-known scientists in the field of aerospace medicine (Doctors of Sciences, P.V. Vasilyev, S.A. Guzulov, N.M. Rudny, N.D. Vyadro, A.N. Babiychuk, Ye.M. Yuganov, P.K. Isakov, I.N. Chernyakov, G.D. Glod, R.A. Vartbaronov, N.I. Frolov, A.N. Razumov, G.P. Stupakov, Yu.V. Krylov, V.V. Kustov, V.S. Tikhonchuk, I.B. Ushakov, S.I. Sytnik, V.A. Bodrov, N.D. Zavalova, G.M. Zarakovsky, I.M. Alpatov, V.G. Doroshev, S.A. Bugrov, I.P. Bobrovnitsky, V.S. Bedneko, V.M. Vasilets, Yu.A. Kukushkin, M.M. Sylvestrov; Candidates of Sciences VA. Popov, V.V. Ivanov, V.M. Usov, S.N. Zagorodnikov et al.).

"It is given to the human to be a Spirit, called to be a Spirit – in here lies the main and the sacred trust of his life". (Flyin', I.A. "The road to the evidence", Moscow, 1993)

CHAPTER 8

IS THERE A GOD IN THE FLYER'S SOUL?

1. Sky. Love. Spirit.

This is my conclusive chapter and, may the flyers forgive me, it is not intended for them, but it is about them. People are not always aware of their genuine value. In this chapter, I do not dispute nor prove this. Consciousness flows from faith, not from knowledge. It is difficult to prove that man's spirit is a power from Heaven, but it is even more difficult to refute it. The human spirit is a true experience of an elevated psychic state, emerging not as a sequence of a deliberate action, but as the learning of the meaning of its activity. The term 'meaning' itself includes a purpose. It is a fact that for the flyer the long-standing fulfilment of flying duties, as distinct from the birds, is not just to earn the daily bread. Based on the need to fly, there is always a striving thirst for knowledge and, first of all, to know oneself. The cognition of self, as a psychological process, concerns feelings, intellect, emotions, and transition to a higher level when conscience enlightens the soul. An ideal world is an image in our mind, without any apparent physical equivalent, though we always perceive and physically sense it as an emotion. This emotion is transformed into physically perceived spiritual pain, blood rush, temperature change, unusual sense of bliss, etc. All this signifies that the Spirit is not only an allegory or a myth, but an historical tradition of family culture, society, and country passed on to us in emotional experiences and relations with other people and events. When we say 'morals' we predominantly mean socially standardised behaviour stipulated by the accepted norm of an historically crystallised time. In the given case, speaking about the Spirit of a flyer or a spiritual personality, I take certain liberties, i.e., imply something high in my spirit, which flows in me, and does not belong only to me. Their perception is not unnatural, most likely quite the contrary, as if in the Spirit there were manifestations, one terrestrial and cosmic, and one natural (body) and ethereal. The highest predestination of the Spirit is in the universal evolution of man, i.e., immortality.

Thus, for a flyer, the essence of his activity, of his life is flying, which is realised in his feeling of freedom. This is probably the explanation for N. Berdyayev's thought (Berdyayev N. "Philosophy of freedom", Moscow 1994) that knowledge is compulsory, but faith gives freedom and alternatives. Hence, emerges the still unresolved meaning of flight: to go beyond the frames of knowledge to the wisdom of freedom's order. The flyers repeatedly experience the surge of an incomparable vigour.

The spirituality of the pilot's personality is displayed in the perfection of his accomplishments. And this is a most valuable quality of this Spirit which, as a rivulet, fills drop by drop the well of the soul with feelings as striving to unearth, to advance, to 'comprehend' his ego in his desire to find his place in the sky. This embraces the perception of speed, of the extraterrestrial space, the gravitational field of belonging to the universe, of feeling his new ego – a freer and happier one. All this is a new spatial dimension of the human spirit where he perceives everything that exists. Certainly, to some degree, this refers not only to flyers. However, in aviation the need of spiritual support is an important requirement of the profession. In flight, the pilot often gets into situations were his instinct urges him to evade danger, ignore moral principles and he succumbs to fear and cowardice. At that moment the Spirit emerges, the genuine meaning of which is unveiled not in volition but in disclosure of the truth about self, about the professional 'ceiling', i.e., revelation! These momentary experiences – who you really are – represent a spiritual process of shedding smugness, self-admiration, and to acknowledge one's blame. The Spirit of the flyer is manifested in his vital and professional experience, not intellectually and academically, but in a more profound and whole state – the love of flying. This state overcomes man just as breathing and love of life. Such an understanding of the Spirit, probably will enable one to answer the question, why the flyers sometime undertake actions which are not in the accepted order of things. Do they today, despite all the complexities of life, still conserve optimism and love of the flying? Furthermore, distinct from the "terrestrial crisis prone person", the flyer, as a

rule, strives to achieve something greater than simply to own more.

Flying safety without threat is a social myth! It is impossible to live and work in the sky without danger. Danger is a system of spiritual heights, which when climbed he acquires new qualities, determines awareness of his potential powers, develops what terrestrial people lack – responsibility and the ability to evaluate the results of his actions (Peccie A. "Human qualities", Moscow, 1980 p 32). Danger is the shadow of the flying man. When a teenager decides to be a flyer i.e., to make the sky his home, he exposes himself to the danger not only to fail medical or professional selection tests, but to get the stigma of 'defective'. To dream about a spiritual beginning, to make amoral decisions and suddenly become 'incompetent' is a great danger for a spiritual individual. Surmounting the danger is just the first step to spirituality – the acquisition of the flying motivation as a goal. The professional attitude generates a higher spiritual cosmogonic drive – love of the sky. Therefore, just the fact of selecting the flying profession fills man with the striving of the unknown, the uncontrollable. And when the youth begins to fly, he is subjected to a moral danger – the realisation of having selected the wrong occupation. This leads to a difficult, painful spiritual conflict over self, giving rise to a new state: "attitude of self to self." This attitude is the Spirit, since it contains the responsibility sensed as a spiritual pain, as a doubt of his mission in the world (Kjorkegor S. "Fear and trepidation", Moscow, 1983). Man overtaking the next danger barrier acquires the ability to hear, to see, to perceive self. This is the essence of the microcosm. He barely advances to the awareness of his Spirit as a source of willpower, faith, and purification.

When the flyer becomes a professional, the crucible of the danger remains as an item of the profession but simultaneously, it transforms from physical into a spiritual victory. It depends on ... self. In flight, the pilot constantly coordinates his activity with moral laws; to preserve his life he follows to the letter the flight rules. Since the rules sanctify the right to choose, the right of a moral alternative in deciding a physical threat to life then, in the sky, the soul bounds man to one and all, and his flying community. This is very well concealed from the surrounding moral force of the flyer. I dare to say this with one aim – to spiritually rehabilitate many of those who were posthumously shrouded with blame. After all, the life of a pilot, especially a test pilot, is far from being always taken by tragic circumstances. Psychological studies of the motivation to refuse emergency ejection leads one to believe that in a sense of responsibility and belonging inherent to the flyer to solve the struggle for life, to the last, together with his aircraft. This is especially characteristic for a situation, which is recognised as the outcome of one's own power. From the standpoint of terrestrial logic, the 'irrational' actions to overcome an emergency situation deliberately lead to an insurmountable situation. These are rare events in aviation, but they reveal a little secret when the conscience, the spiritual beginning, the invasion from the solution of a moral dilemma, is rated as a betrayal of the high goals of flying. I realise that many of my readers will not share my opinion, but I hope some may accept and agree.

For philosophers, it is a good illustration of I. Kant's thought that "one man is responsible to mankind with his person" (Kan I. "Proceedings" in six volumes, Moscow, 1965, volume 4, part 2, p. 184). But, on the ground, the behaviour of the flyer in an emergency situation will be judged by other people, guided by written words with the spirit of aviation laws. They do not want or can't understand the real needs of the flyer, the meaning of his fate. This is a socio-psychological danger, to be misunderstood, subject to coerced landing, to have a bright, original personality destroyed. This danger torments the soul, as there is nothing more immoral for the flyer than the spiritual violence, since it is unusual for him.

Lastly, the danger of parting with the sky is a constant danger hanging over the head of the flyer. It is a most excruciating danger, eroding his soul. It is especially characteristic when it occurs in the state of complete exhaustion (Ponomarenko V. "Psychology of the flyer's life and work", Military Publisher, 1992).

Man feels that a flight mission gives him no pleasure, he spiritually forces himself to go off and fly as a slave labourer. In such a state of fear, of lack of confidence, he shifts the responsibility for the mission's outcome to others. He loses the concept of time, the past gains over the future. This is a spiritual danger, since it is a transformation from high to low. The evil covers the sky above, while leaving the soul black in muffled emptiness. The life's reality is filled by a sensation of shame for passing from the scene which generates a psychological attitude of pitiless self-evaluation of his personality. And the spiritual life of the flyer confirms Lewis' assumption that "we correctly see

ourselves only in the moments of shame" (Lewis C. "Love. Suffering. Hope", Moscow, 1992). This is a loss of an idea in its essence. God forbid if you survive this, as very few people will understand and back you. In connection with the above, I wish to widen the horizon of those who understand the Spirit of the flyer and recognise his specific spiritual world.

Unfortunately, science with its disciplines (biology, physiology, psychology, anthropology, and sociology) does not prove the cosmogonic organ of the psychic, spiritual principle. The psychic development of man has been considered in the history of evolution, relating psyche to a secondary derivation of the material existence, virtually ignoring his individuality. Hence, emerge the methodological obstacles, since all that concerns morality (good and evil) and spirituality in the history of thought and culture to the religious philosophy where man is a revelation of God. As a result, it turns out that to understand the spiritual nature of man in general, and that of the flyer in particular, the sanctity of his mission as the creator of good for others, without profit and arrogance, is almost impossible without solving the intimate question – is there a God in the flyer's soul? If God is good and reason, then the answer is positive. That is why, in my hypothetical portrayal of the inner world of the flyer, his second 'ego', I cannot dispense with the religion history, and with notions as 'freedom', 'faith', 'fear', 'sin', 'evil', 'good', etc. There are many religions, but since the one I know best is Christianity, I will rely on its myths in revelations learned partly from biblical legends, but mainly in the enlightened interpretations of humanistically oriented philosophers and thinkers. Moreover, I am interested in the all-inclusive relation of life and the human Spirit with the universe as an eternal and a continuous phenomenon. Visually, the universe is presented to man as sky and stars. "The sky – wrote Russian religious philosopher N. Berdyayev, – is the deepest depth of our spiritual life". In this depth, resides the spiritual experience differing from the earthly reality as a deeper, broader layer of existence (Berdyayev N. "Gist of History", Moscow, 1990, p.35). Following the intuition of the thinker it is possible to assume that passion for the sky, the fear of the sky, and love of the sky are manifestations of man's spirituality.

The sky inspires, i.e., manifests itself as a "Self-spirit" (Stainer P. "Theosophy", Moscow, 1990). In ancient times the sky was feared because of an invisible spirit, yet, even the sensation of fear was sanctified. Therefore, if we accept the sky as a form of our spiritual life, then it follows that through spiritual communication with the sky, man may receive information and energy from the kindred spiritual world. Hence, the understanding of eternity and continuity of the universe, of space, and of time. But spiritual communication occurs not only with sky but also with one's inner 'ego'.

The essence of man may be understood through his activity. When man became an earthly being, he became dependent on the biologic any social environment. The profound moral roots have their beginning in spirituality i.e., in the independence and in the freedom of choice. Therefore, man is a true microcosm, the object of which is the universe. As to the cosmogonic origin of nature, it is reflected in man's consciousness as his link to the world, to his eternal and continuous existence. What is the connection of all these thoughts about the spiritual nature of man with the flyer's spiritual world?

As I mentioned earlier, man in the sky is a special man, he feels and experiences differently the physical world: speed, altitude, time, space, and the universe. He senses fully its warmth and its energy, and perceives himself as a microcosm. But, since the unusual physical flight world is transformed into sensations different from the terrestrial ones, man begins to fear this, and is ashamed of his unusual feelings and at times suppresses them and 'stashes' them in his subconscious. The paradox here is that the 'addiction' to heights lies hidden in the subconscious and is sealed as a subconscious taboo. Thus, from the depths of the subconscious arises one of the oldest senses – anxiety – fear of the unknown of what is beyond consciousness. This fear is not cowardice, but a feeling of danger. In is fear which leads to a changed state of consciousness. Thus, man releases all these extraordinary sensations in the form of dreams, meanings, omens and premonitions evoking a state of veneration. This evokes the pull to extraterrestrial communion, the transfer of man's consciousness to the pulsating universal consciousness. As an example, I shall cite data taken from the story of a well-known "flying writer" newspaperwoman, parachutist-jumper and a great connoisseur of people in aviation – Nonna Oreshina:

"Recently I have taken a course of a special type of meditations concerning unrecognised blocks of the subconscious on the genetic memory. Moreover, you may visually see and sense

something from past lives and much more. When I placed myself in the needed state of mind in the first session, I imagined myself clearly and truly as a bird soaring near mountains by the seashore. I saw the rocks in meticulous details, perceived their dangerous proximity, in descended air currents, felt each flapping of the wings. I knew that I was in a room, I heard the music, I was aware of the other people in the room, but all this was in a distant and unreal expanse, as I was flying amid cliffs. My arms were making flap-like movements, and each finger perceived the destiny of the air as though I turned my 'wings' in such a way as to be able to bank, dive, or climb. Furthermore, the scenery below was not as seen from an aircraft, but from the bird's view. My reflections were not as if I was steering an aircraft. Then, and even more so now, I was convinced of my old assumptions that he, who from an early childhood wishes ardently to fly (though, probably, is physically unfit for flying duty), had been a bird in his spiritual evolution. You may believe this or not but for a flying career is necessary to have a flying talent, a certain spiritual state, and a peculiar philosophy of life – this is all indisputable".

All flying commanders and instructors are typically cautious of excessive autonomy (freedom) in the sky. The first 'bumps' the flyer's experience and is due, as a rule, to the inability to manage freedom in flight. Figuratively speaking, freedom urges many flyers to break rules. For example, zero-altitude flight, aerobatic manoeuvres in the clouds, shortened takeoffs, etc. The Spirit of the flyer, his will to live is related to freedom. Although these outbursts are concealed from the surrounding people, in the long run they can manifest positive and negative forms of behaviour. Many cannot grasp the deeds of the flyers, mainly because they do not understand their spiritual origin. The first overcoming of self, the ability to overcome fear in the face of danger, unheard-of destination with flying, state of elation, state of emancipation leads to impulses of heroic actions to overcome any danger. However, in real-life, this is manifested by a reduction of self-criticism, a dulling of alertness, and even bragging. Flying is not only exciting and ecstatic, but it unavoidably leads to a feeling of superiority over the people who were borne to 'creep'. The spiritual experiences of joy, power, readiness to face calmly death and victory without psychological reactions, might develop self-admiration narcissism. However, the same experiences, in the case of a breakdown may evoke a feeling of inferiority, phobia, guilt, and sin. Every flyer is familiar with the feeling in an emergency situation that there appears an inappropriately feeling of culpability or of hesitation in the choice of a course of action. This is often explained by aviation accident investigations, but probably, the psychological phenomenon lies in the deeper strata of the second 'ego' of consciousness. The same applies to the anxiety, which is far from a manifestation of unconscious fear, but more probably an exhaustion of the prevailing earthly worries over life in the sky. The consciousness of the flyer reflects the mythology of the divine genesis, and his freedom still represents a degree of danger. It is as important to train special mechanisms which prevent the lack of discipline. The philosophy of man in the sky concerns the laws by which he flies. These laws need to be understood as the improvement of the pilot through the enhancement of his spiritual maturity, and then only of his professionalism. Why? The higher the sensory organisation of man and his soul with which he estimates space and time, and the broader the sphere of potential encounters, the more diverse the environment acting on the organism and on possible adaptation (Sechenov I.M. "The selected philosophic and psychological publications", Moscow, 1947).

In flight "the sphere of potential encounters" is a menacing space. That's why enhancement is an increased degree of freedom to neutralise this danger. In short, this requires a comprehensive education, starting from the control over instincts and ending with the education of the soul.

What is the cost for the need of risk: total freedom? Risk, as the aspiration of freedom, is the essence of a creative life. And in this spiritual property is the key to understanding the thought expressed by Schweizer when he wrote that the cognisance man acquires because of his desire to live is much greater than the knowledge obtained by observing the surrounding world (Schweizer A. "Adoration of life", Moscow, 1992).

Therefore, the spiritual enhancement is an ethic norm of man, a psychological norm of the development of an individual supersensitivity. Now I can better understand the deep, spiritually experienced thought of the Soviet flyer M.M. Gromov: "In solving the problem of flying safety, we need to improve man's psychic activity by higher education and self education, and improved technology based on man's psychic activity. The flying profession improves man by

shaping his psychological make-up (Gromov M.M. "About the flying profession", Moscow, 1993, p.7)."

What does it mean to improve psychic activity? Usually, this term includes training of memory, attention, will power, emotional stability, 'feeling of aircraft', preservation of motivation, and commitment to flying duty. But it is difficult to find recommendations for the spiritual training of self.

The spiritual basis for self-education is, first of all, cognition of one's 'second ego', which is also your Spirit, since it gives birth to the love of flying. The second 'ego' is a special willpower limiting one's freedom, i.e., a spiritual means of conscious control of one's senses and actions. The second measure of 'ego' is the awareness of one's ability to do some good, and it is a personal omen of ones name which one must not treasure less than life. Spiritual work will certainly lead to the possibility to recognise the highest feelings as sin and fault. Sin is not evil. Sin consists in the fact that the Spirit gave evil the chance to use freedom to behave unwisely.

The pilot is granted a sense of humour as a spiritual censure of his weakness. Humour helps the flyer to understand the English adage: "to sin is human, persist to sin is satanic". Do not fear to perceive the Spirit in self, since it is not something from the hereafter. In spirituality the soul is enriched due to commitment to love, labour, and service (Men' A. "Culture and spiritual ascension", Moscow, 1992). There will come a time when aviation people will be proud that the flyers were the first to understand that each of them has God in the soul and this is greater than "Solomon himself".

2. The Concept of Space as a Psychological Problem of Universal Consciousness

According to Fromm, recent ideas concerning man's future (human international cooperation, positive and 'individual initiative') were associated by scientists to the metaphysical world of man. Neither Homo sapiens, nor the economist could thus far refuse material goods in favour of spiritual fulfilment. Today, humanistic psychology and religious philosophy blame the enlighteners of the XVIII and XIX century, as owed to their humanistic concepts, man was separated from God, and placed in the centre of the universe, thereby destroying the harmony of the highest principal. Man has loved self, power, and has made pleasure his highest goal, and has virtually satisfied all his sensual desires. Man has forgotten that although he is a child of Mother Earth he is only a guest (Men' A. "Culture and spiritual ascension", Moscow, 1992). The modern man is immoral, since he wishes to depend only on self. He is passive, spiritually drained and absolutely indifferent, rather a follower than a leader. In the opinion of the Danish philosopher S. Kjorkegor, people are not good because they are far removed from faith. They are even unable to show spiritual humility. Weakness is not an 'empty word', when people have even defeated God with their weakness.

Currently, in the interest for the global transformation of the human communities, the humanists have advanced a new goal: to subjugate technology, economy, and irrational social forces (Fromm E. "To have or to be", Moscow, 1990). This is a new human utopia. However, I wish to formulate my 'aviation utopia', which I shall present here. Mankind, for a long time, has been dreaming about flying in a vehicle heavier than air. This dream has become a 'reality'. If a banner is raised to create a new humanistic society, why not recognise the flying community as deserving to represent its new citizens? But this requires some prerequisites. The flyer is a man with a conscience, who thirsts for power, but only over himself. His 'inner ego', his Spirit of freedom, is concentrated on other people, his consciousness is tuned on the universal frequency. The flyer, as the achiever of highest goals, personifies love and love of life. The greatest vice of man is arrogance, but many proficient flyers successfully restrain from it by embracing the aviation moral imperative: the higher we rise, the less we appeal to people who can not fly. This is an astounding psychological phenomenon of spiritual continuity.

However not all can accomplish this. Let us try using an unusual approach to aviation work by searching for spiritual qualities, new properties of consciousness, which do not isolate man from other worlds, but bring them close. L. Gumilyov, scientists-ethnographist, (son of two Russian poets and mavericks Anna Akhmatova, and Gumilyov, the latter was shot for alleged participation in the counter-revolutionary coup) has called the mental striving of man's community ideals 'ethnic dominance' (Gumilyov L. "Ethnogenesis and biosphere", Leningrad, 1992). Thus, already before

me someone tried to demonstrate the specific quality of the flyer's consciousness: the creative search for cosmogonic information. As an example, I have opted for the idea of space.

For a methodological principal of the systematic analysis for a transfer from the theoretical to practical reality, I choose the principal of continuity by giving it a special quality. In order to know or to forecast the objective process, it is always necessary to fall back on available knowledge and ways to obtain it. In this case, the principal of continuity acquires a special property consisting of a quality that enables understanding of the previous knowledge, i.e., continuity acquires a psychological need which is followed by new knowledge. I shall try, based on my 'discovery' of the methodological analysis of future phenomena, to consider space for the practical application of man's movement in the 'ocean of air'. The psychological aspect usually deals with spatial orientation, since, in more than 80 years, there have been about 15 to 20% of the yearly aviation accidents with human losses due to spatial disorientation. The psychological monopoly on this problem led to the fact that space, as one of many world ideas, has lead to the problem of analysers. However, spatial orientation entails also mental transformations of visual information. Man's orientation in an aircraft or a spacecraft requires an active awareness of constant intellectual self-evaluation of the movements in space.

In flight, the pilot experiences a controversy between the visual and the instrument information, between perception and reasoning. It is caused by the substitution of a point of support, when the vector of the dynamic force perceived by man is Earth's gravity. The psychological response of all the mechanoreceptors 'tells' the truth, which belongs in the so-called flight image. This is briefly the essence of the problem of the psychological interpretation in spatial orientation.

However, investigating aviation incidents and accidents, the rich palette of spatial illusions, the psychic states, which pilots and cosmonauts do experience, brought me to the conclusion that it is difficult to improve safety when leaving the Earth without a profound understanding of the idea of space. After all, space is a part of the nosophere, since it embraces the social strivings of man, the idea of religious transfiguration, of existence, and even sin, and the idea to reach the best reasoning power. Therefore, let us consider the meaning and feelings of men who conquer space. What is the psychology of the conqueror's feelings?

First of all, aviation has imparted to these abstract categories, 'space' and 'time', an individual meaning as, for the flying man, these categories are of social value because they are psychologically included in the goals. Space, in the opinion of pilots and cosmonauts, has become accessible. "Flying," wrote pilot B. Yeriomin, "gave birth not to an illusory, but a real accessibility to any point on Earth at a demanded time – wings and engine have changed the reality" (Yeriomin B.N. "Aerial combatants", Moscow, 1987, p.5). In the opinion of cosmonaut G. Beregovoy, man was condemned to work only on Earth, but now he may live in the universe. For the flyer, the psychological transformation of the physical essence of space is an intellectual process of understanding and self-realisation, as an individual and as a social asset. Pilots and cosmonauts are humanising space, calling it home. Space and time in flight are an informational category with a profound social meaning: preservation of national security, and prevention of the causes of catastrophic ecological situations on the planet, etc.

Therefore, space may be designated as the new area of investigation for the formation mechanisms of the planetary consciousness. The sky is a common space over the planet. Hence, aviation and cosmonautics assist the flying man of any country to develop humane feelings in man, honing moral demands, and understanding of self in others. This profession may serve the purpose to save the human capital, to create, as per Antoine De Saint-Exupery, the "Planet of the People." It seems to me that this generalised aspect of the spatial orientation problem, particularly in aviation, might advance the solution of special practical tasks.

In this connection, I wish to mention another non-traditional idea, related to the influence of space on the flyer. It is well known that the cockpit represents the environment in the form of encoded symbols, characterising the movement of the flying aircraft, the levers, and the control sticks handled by man and, lastly, the informational data which controls the 'flyer – aircraft' system. In the given case, the environment surrounding the flyer is nothing else than the acquired knowledge of steering the aircraft. Since all the information is encoded, the mind (psyche) is busy with transferring the information into mental images. The entire process starts here. In the image all is

richer, brighter, broader, and, what really matters, man understands that his knowledge is insufficient, since the essence of space is much greater than the indications of the spatial attitude indicator. The pilots begin to perceive, not physically but spiritually, that the cockpit is small and stuffy. Mentally, he unties himself from the seat, as if he were leaving his body and beginning to soar. This is a miracle which is unfathomable for the earthly mind. To understand this, the mind needs to appeal to the universal awareness. Lack of knowledge of the visible, perceptible, tangible space should be compensated by a feeling of the highest order – faith. In the given case, under faith I mean the psychic state of revelation, i.e., meeting what is higher than our intellect. I am asking my readers not to be fearful should they think that the pilots do 'fly out' of the cabin. The experiments I have carried out in flight did not confirm a lot of these things, but they were not meant to do so. However, in observing the life of the flyers, especially test pilots, I felt their exceptional creative individuality, wholeness, the degree of their awareness, a specific talent of sensory perception of the world, and a striving for cognition – which spreads beyond the limits of the sensory perception. In other words, I intuitively sensed, but feared to admit it to myself, that I had dealt with a phenomenon of religious consciousness.

As an investigator, I anticipate that the farther man goes beyond his planet, the more he will experience the influence of factors unknown on earth. For example, the change of gravitational fields, deformation of the perception of spatial structures in familiar objects, changes in time perception, distortion by the biologic sensors of informational flows, slowing down or acceleration of cellular vital functions and of metabolic processes. We are also nearing the discovery of living organisms of cosmic origin. It is time to try to break away from the captivity of the usual metaphysical postulates and rise to the level of the universal mind, since only then will we see the diversity in the degree and type of body and psychic reactions: the evidence of future evolution.

The problem of spatial orientation of the flyer is an exceptional 'instrument' for learning the adaptation of the capabilities of man. The process of spatial disorientation, namely the breakdown of the psychic reflection of himself (pilot) in space, and the process of the disintegration of the conscious and the unconscious, and the disharmony of the biologic and social splitting of 'ego', and the formation of the 'false world'; becomes the key to solving the spiritual sources of man. It is not an accident that the enlightened people on earth included in their communicative, spiritual, and material activity the planetary reach for the solution of the cosmos as the beginning and the continuation of the highest intellect limiting the potential development of Homo Sapiens. Unfortunately, at the beginning, the practical mastering of a cosmos was aimed not so much at penetrating the spiritual essence of the space traveller, but as to solve the technical problems.

Space enables us to state the problem about the prospective investigation of man as the carrier of the universal mind, and as the individual receptacle of the Spirit. From this, all the achievements of space psychology are nothing more than the initial results, since the model was an artificially created earthly life. During space flights, direct communication from Earth to the cosmonaut was not interrupted. But the fact remains that our scientific thinking has given priority to the biologic genesis of man, and correspondingly has based all training programs on medico-biologic concepts. All those who saw and perceived the triumph of the recognition of the spiritual kinship, the communal understanding of the planet Earth after the space flights of Yuri Gagarin and Neil Armstrong, the joint USSR-USA space flights, permit me to express some interesting thoughts.

The space era has contributed a logical cultural concept of the people's rapprochement instead of estrangement. I do not believe that this may be considered a transformation of political motivations but rather social 'mutations' of the mind. The spiritual outcome of mankind's penetration of space is the development of the energetic potential of our planet's culture, the creation of real premises for moral imperatives capable to lift the people to a new level of the highest intellect. The core of this imperative is the leap of the earthly rational intelligence to the spiritual mind, in the interests of a unified community that recognises and reinforces the meaning of life in the universe. However, to investigate the spaceman, it is necessary to change the scientific paradigm by shifting the emphasis from earthy psychology to space psychology. Once more, I need to discuss methodology. I believe that for interplanetary travel, conditions will be created to sharply reduce the effects of the earth environment, and conditions for a closer exposure of the organism, and even of the cells, to the space environment. This will allow to determine the dynamic values of the psycho-physiological

reserves, and also to form new structures determining other forms of the organism's existence in an unusual environment. For these investigations, we should use subjects with extrasensory perception. The novelty of these investigations will consist of studying physio-chemical states, especially temporary deformations of the active protein structures in space.

In other words, in space one may solve problems of the cosmic origin of living substances. And, if possible, to discover the biologic code, and then we should direct our efforts to regulate the metabolism, and enhance the tolerance to earthly professional dangers. In this lies the great significance of space expanding the possibilities to prolong life, adding further meaning to man's existence and to his development in the new role.

Space plays also an important role in planetary awareness, the formation of theological theories for intellectual atheists, and the new moral space of the spiritual development on Earth. Space has the key to unlock the psychic code which was lost for unknown reasons, and we have only a fraction of the past mind for our vital, reproductive, and egotistic requirements.

In this connection, the psychological program of the investigations in space should consider the solution in the form of new procedures for the development of new qualities in psychic communication, noise tolerance, and communication with the aircrews to build a new spiritual environment. Also, the substantiation of theoretical aspects to establish a link with the earthy man's existence with the mystery of our origin needs investigated. Equally important is the role of space in the creation of new spiritual theories. Mankind needs a new moral space for the spiritual unification of the peoples on earth. Special hope rests with future psychological investigations on the issue of the synthesis of the natural, the biologic, and the physiological knowledge. The object of these investigations should be the space as a psychological problem of planetary awareness.

Man in space starts to spiritualise space. There, up high, he perceives earth as a part of his 'ego'. This is a creative field for future philosophers. In space, the interchanges of communality to individuality, idealism to materialism, are so perceptible that they allow for an approach to the problem of genesis of the communal planetary soul. It is a pity that our post-flight, medico-psychological investigations, is more oriented at biologic waste than at the spiritual acquisitions. It is reasonable to examine the emotional transformation of the cosmonauts even short-term. These 'grains' of insights will give the impetus to establish programs for the cognition of personality, and freedom of will power. Since the problem of the usefulness of qualified cosmonauts remains the same, thus begins the selfless era of psychology.

Man's space and near earth flights, at first, were to create conditions where nations, ethnic groups and individuals on earth, appreciably accepted the thought of a common soul. The cosmonaut having received the impulse of cosmic awareness, convinced us, that not only earth is inhabited by man! Life in the sky has substantially transformed life into a meaningful existence. It is not an accident that the first words spoken by U.S. astronaut Neil Armstrong, after his successful lunar landing during the first extravehicular activity on the surface of the moon, said, "One small step for man, one giant leap for mankind".

3. Spiritual Renaissance

Advancing the thought of deep-rooted broadmindedness and generosity of the flying man at the expense of his regular and prolonged switching on the informational-energetic space field, I became convinced that the flyers of any country may actually 'feel' each other. Let us consider the actual capabilities of people with a powerful biologic field combined with an ethically oriented spiritual force to favourably effect the surrounding environment. I am not a specialist in the occult and magic sciences, nor do I possess skills of extrasensory perception, but I am convinced that not all presently unknown is 'shamanism'. It is time for psychology to stop turning away bashfully from the problems of man's soul, and from unusual powers of clairvoyance, fusion with the universe, etc. We always treated consciousness as a reflection and transformation of the material into the ideal, and were very afraid to think of it as a vehicle for the communication with the extraterrestrial world. It is even more scary pondering, (but so far no one has even contemplated it), over the meaning of life and of man's mission. In the magazine "Party Life", issued during the period of the Khrushchovian thaw (Khrushchov was the fourth Secretary-General of the Communist Party of the Soviet Union), was a list of material goods, from the number of shoes to that of rooms, each citizen will

be given, free of charge, by the Communist state. And not a word was spoken about the soul, the moral problems, and the freedom of the individual. This meant that man was only a 'thing'.

Darwin's theory on the origin of man from an ape has slowed down the spiritual evolution of man. However, to the present, anthropologic sciences cannot give a convincing explanation, why the 'animal' in man retains nature's conformity: continuity of the species, group reaction to danger, gesticulated speech, while the psyche causes a lot of misunderstandings and grief. Even the word often becomes a stressor, a tool of lies and trickery. At the same time, the unwise animal, in its purposeful behaviour, creates a common survival trait – a biologically specific 'vigilance'. The activity of each ant forms a cooperative pool. In human society an individual cannot organise a single whole. But, what is most difficult to understand is why is there no reciprocal spiritual understanding among humans?

Psychology, as a science, has directed too many efforts to study the man's psychic functions as a secondary reorganisation of energy, assuming that the psychic processes are mastering mechanisms of the social and historical experience of the individual. Yet, not a single socio-economic society has been able to establish, over thousands of years, that human relations are based on moral ideals. For centuries, man has tried to change the world, not understanding the main principle – is the world for us, or are we for the world? But the world is just us. Therefore, if changes are to be made then only to 'self', meaning: "Man on whose side are you?" This choice will decide the success of penetrating space. And this hypothesis is supported by the fact that mankind currently has started on the path to find the highest assets. The need for a new faith is thus born.

If we carefully examine the scientific physical and biologic discoveries, they do not refute religious myths, furthermore, they even partially supported them. It is believed that the XXIst century will be the era of psychology. There is hope for a psychological 'sanitation' of the humans exposed to massive 'doses' of the informational and energetic field of the earth. Modern science and practice have already prepared a definite scientific basis for it.

Once, the Russian geophysicist V.I. Vernadsky has advanced a hypothesis on the origin of the universe. Living substance was brought to earth from the depths of space, however not in the form of molecules, but in the form of biologic fields. The field, in physics, is a 'portion' of space with differently acting forces. In the universe, there are two realities: matter and the field (Albert Einstein). The matter of the biosphere consists of two states: living and cosmic. They are mutually joined. The cosmogonic gist of the biofield of the living matter is represented by man's intellect which, in turn, transforms the biosphere into the sphere of the universal intellect, i.e. into the Nososphere (Vernadsky V.I. "Space and Time in living and non-living nature", Moscow, 1975).

Matter, time, and space are the universe; information and the Spirit are its content. In the opinion of S. Lazarev, the process of identification with the universe is the forerunner of civilisation. But, most importantly, human life is a certain objective transformation of the information in the matter. It is assumed that the manifestation of the Spirit in the matter is a basic affirmity of life. Physical adaptation of man (health) is related, first of all, to the effect of the information from the universe about the spiritual structures of man. (Lazarev S. "Diagnosis of Carma", St. Petersburg, 1993). Here lies the essence of the entity of world and man and of his participation in the continuity of existence.

The relation of the cosmic energy with the field of the living matter is realised through spirituality. Hence, merges the objectivisation of the physical spiritual forces. This, however, did not keep Taillard de Chardin to express the idea that the origin of life is a result of the "spirit's takeoff" crowned by the appearance of man. According to Chardin, the matter, that is, the field, is a matrix of the spiritual principal (de Chardin, Taillard "Phenomenon of the human", Moscow, 1965). As the physical energy of the field in the universe dissipates, its evolution is supported by the spiritual energy. This energy is inherent to a cell and to a molecule, and in the new matter this energy acquires the form of consciousness.

Science has established that there exists a cosmic medium and a physical field. Man, as any other material system, is a part of the physical field and, in the given case, of a cosmic field; for the physical picture of the universe is formed from fields (Gegemain G. "Concept of living matter field" //Herald of Russian academy of sciences, 1993, N2). But, beside the physical field in the form of biomorphostructures man has also a spiritual field consisting of love, suffering, exaltation, goodness,

aggression, and bitterness. All these and other states in the spiritual field are found in the dynamic process.

The highest destination of the living spiritual field in man consists apparently of the organisation and the coordination of a balanced state of goodness. The energy of evil disturbs the equilibrium. This is facilitated by the universal quality of man's biofield. My 'ego' is also the 'ego' of other people; this is universality (Hegel). A fundamental quality of the spiritual field is a merger of good and evil (Ilyin I. "Road to evidence", Moscow, 1992).

This permits me to formulate the methodological and theoretical concept (hypothesis) about the objective capability of men with extrasensory perception to restore, with the help of their energetic field, the field of other humans who have lost their dynamic balance and have gone beyond the limit of 'spiritual legalities' in the area of evil. I call this hypothesis the "Balance of Spiritual Fields". This balance serves as a mechanism of the organisation of the universe. The Spirit, in the frame of the human substance, counteracts the chaotic condition of the soul, exceeding the admissible moral limits. Taking into consideration man's universal association with good and evil, man is capable to receive the energy from space and pass it on to another person, thus achieving equilibrium in his soul. Postulation of a spiritual field's balance is considered, by some investigators, a main prerequisite for mankind survival. We talk "about renouncing the earthly conditions, to become one with the cosmos, to acquire knowledge, to incorporate it into moral laws and use their practical realisation at all levels" (Lazarev S.N. "Diagnosis of Carma", St. Petersburg, 1993, p. 37).

In other words man, in principal, possesses a supersensibility capable to change a chaotic situation into balanced calm, as demanded by his mission. He may reproduce goodness and thereby control evil, yet he may also proliferate evil. The positive and negative charges of such fields may enter interconnecting local spaces, in which live humans, animals, and plants. The negative charge of such space creates conditions of adverse influence on all they contain. The form of influence may be diverse and displayed in psychic, as well as somatic and biologic spheres of all living organisms. There are known examples where humans, united independently of their will by a wicked force, generated powerful negative fields in which even the good becomes evil. Vice is contagious – this is a social fact. In this case, the people having special sensibility to field states are capable to regulate them. Moreover, according to data obtained from persons with extrasensory perception, they are capable to protect humans, animals, plants and even inanimate objects from evil influences. But, to do this, one needs a powerful positive field, or, more precisely, to be a carrier of such a field.

A renowned investigator in the field of extrasensory perception and of its application in the 'energy treatment', S.N. Lazarev, determined the needs of extrasensory people as follows: "They are humans with a pure Carma, with developed spiritual patterns, strategic thinking, spiritual goodness, and great self discipline. The ability to exorcise an evil spirit, to control it by energy, is only inherent to those humans who are able to observe and to follow the highest ethical laws" (Ibid. p. 40). All this reasoning is based on facts observed with extra-sensitive persons and the results of their work. The future of science consists in the objectivisation of the scientific explanation of the physical basis of the spiritual fields and of their equilibrium.

For a man with extrasensory perception, there exists an additional possibility to draw information about the soul from the repository of the unconscious experiences. The fact is that the energy of the spirit, transformed in the soul into unbalanced forces of good and evil (each in its own combination), transfers from one person to another through speech or action. Here rests the human life drama, which the negative field may transfer through energy charges, i.e., we stabilise the phenomenon of induction. The human with the negative charges may, without intention, even without suspecting it, create among others a negative field in which all subjects, also be inanimate, may be subjected to 'wicked influence'. This is not a myth, this is a reality, since the human mind, wrote the Russian prominent geophysicist, "is a geological force" (V. Vernadsky). An object of the field effect is basically not an individual and his consciousness, but a subconscious sphere which serves still another logic prerequisite of the existence link with the universal awareness.

In this connection, very interesting data were obtained by S. Groph who studied the psychic experiences of patients under the influence of LSD. This drug, acting on the subconscious, produces regressive memory and sensations including religious ones. Painful experiences, as illness, hurt

feelings, sensations of suffocation, and cold are sublimated and many may manifest themselves years later as a disease and unmotivated behaviour. I was interested in the experiments by S. Groph (including those he conducted on himself) about cosmic memory regression. The states were characterised by experience of cosmic unity, serene bliss, sensation of pure existence. Those who have experienced these perceptions described them as Infinity, loss of their 'ego', broadening of awareness, as if it had become consciousness itself. They perceived themselves as cosmic beings, receiving a charge of wisdom. In some cases, they felt a state of ecstasy, when a subject identified himself with God (Groph S. "Beyond limits of the brain", Moscow, 1993).

My colleague, Professor L. Grimak, studied the hypnotic suggestion of weightlessness with subjects who had never experienced it (Grimak L. "Modelling of human psychic states in hypnosis", Moscow, 1978). The investigations of the biochemical and the vegetative reactions of man in a state of suggested micro-gravity, demonstrated that the functional states of the cardiovascular and locomotor systems approached those observed in actual space flights. These data 'torture' me. The fact is that observing the emotional state of the flyers with their personal experiences at altitudes above 15,000 meters in fighter aircraft and high altitude hypoxia, I have come to the conclusion that one of the first observed phenomena is the "flight of the soul", removal from earth gravity, feeling of glee, and what is most important – the thought about meeting another world. In 1967, I conducted an experiment on myself, while breathing hypoxic oxygen and performing control operations in the cockpit of a simulator. Since I was aware of the fact that I would lose consciousness, I tape recorded all my feelings. I briefly described the changes I experienced. I did not have any signs of euphoria. I only noted that all my reactions to the flight parameters were delayed, (the critical sphere was preserved). Then, gradually, I felt the sensation of light-headedness and a slow detachment from my flying tasks, which I was still performing. And finally, came the transition of reality to surreality with light illusions, hollowness, infinity, sensation of a new dimension, another space... another life. I did not feel the loss of consciousness. I recovered consciousness after breathing pure oxygen. It seemed to me, that I was in an amnesiac state, since I could not remember what had happened. I could recognise my experience only after listening to my own tape recording. Later, in a joint investigation with researchers of the Russian Academy of the Sciences Institute of Psychology, we studied analogous conditions induced by breathing hypoxic oxygen (Research and Development report under the code-name "Cropper", 1990, the main investigators, V. Stepanov, A. Fedoruk, T. Timofeyeva, A. Lebedev, T. Ushakov, etc.). Something 'extraterrestrial' had occurred. Usually we observe strictly phased character changes in the emotional volitional sphere of the subjects (less criticism, good humour) in the sensory motor activity (locomotor disorders and dysrhithmia) in the psychic sphere (slow reflexes, alienation, seizures, stupor, and coma). But there are also other manifestations, when reality is not gone but superseded by a new form of pleasant dreams. The sensation of soul release did occur. Fortunately we detected no physical equivalents of the above-described neuro-physiological states. Therefore, in this area, we can only hypothesise. I would like to emphasise a rather strange fact: as the severity of brain hypoxia increases, the reflexes decrease markedly (T. Ushakove) while, simultaneously, the test subject feels the 'appearance' of another consciousness, which is from another world. Apparently, at this moment, the informational link to the psychic biofield with the cosmic one is realised. These observations have suggested that the 'flying human' absorbs the cosmic energy, becoming a natural extrasensory 'carrier', sharing the particles of the universe's field with his surroundings.

In the light of the above, it seems appropriate to formulate the higher level of generalisation concerning the flying safety problem, as well as safety in general, in its physical and spiritual dimensions. The investigation of the flyer's safety may become the intellectual bridge for the corroboration of the general concept of safety on planet Earth. We should start with the elaboration of the concept of the spiritual language, the understanding of the general idea of the human mission as a spiritual force, which opposes evil. Today, this is extremely important since, even amid the flying personnel, a career in aviation is becoming less and less attractive. Commercial profits, lowered values of flying, and disrespect of the aviation spirit lead to the devaluation of the flyer's 'ego'. However, daily life demonstrates that an immoral human is less dangerous than who uses evil deliberately. There is no greater sin for a flyer than to transform the sky into a personal gain, making it not only a tool but also its life goal. If this were to continue, aviation would become a

mere means of 'transportation', only more dangerous and unpleasant. It is painful to write about it, but it is even more painful to think about it. My special hope rests on the flying staff that has not betrayed the sky. Therefore, trusting in the best that remains in the flyer's spirit, I continue to work for the safety of all mankind. I am speaking about the formulation of the spiritual theory for the generation of mankind's highest goals.

If we, the psychologists, wish to advance the ideas of good, we must support and match our theories with common sense. Psychology should investigate the human Spirit as a source of the development of earthy life and its values. The Spirit is a vital force, not a power over others. The Spirit is force of character aiming at humility in its 'ego'. The Spirit is the highest sense of dignity, yet ready to repent. Thus, gradually, we shall significantly penetrate the subjective world of the human being.

As an example of the subjective world, we shall view the phenomenon of repentance. This is my interpretation as a clinical psychologist. Repentance is a painful spiritual process when the 'ego' woven by your conscience has left you with a tortured soul eager to rise to its 'ego' and fuse with it. Probably, at this moment, God is born in man. Repentance is a psychological process, since the soul is trying hard to be aware and to understand its sins. There seems to be a grain of truth in Apostle Paul's words: "Repent by renewing your mind, care to have God in your Spirit".

The peculiarity of the human Spirit consists in connecting us with the universal awareness. The theory of the objective image of man's subjective world may offer a positive result, and today, the understanding of the relationships of the individual awareness with the universal consciousness as a nosospheric mechanism of the eternal flow of life, of that which was, is, and will be. This is not only a cognitive scientific problem but also a practical one, since its solution is linked to the fate of a new language, the language of consciousness which will help people to acquire the gift of understanding not the end of life, but its eternity.

We need to consider some new quality of memory as the guardian of time. This will lead to a new concept of past time. The past, stored in the memory, is a link of the existing awareness of a separate personality with all mankind. The language of awareness is simultaneously a means of switching to the bio-energy of the highest intellect. And, who knows, possibly by creating a new language of awareness; psychology, as a science, will succeed in developing a method for a prolonged preservation in the human soul of the universal good, whose potential is greater than evil. Undoubtedly, evil is ineradicable sense in spite of it all, and bears the differential sign of good. Therefore, the role of good, in the opinion of enlightened thinkers, is not so much a struggle against evil, as a limitation of its area of influence.

Probably, we should broaden the psychic image and pursue the investigations of good in evil. "Under Good", wrote Spinosa, "I mean all which brings us closer to the image of the human nature, under Evil all which hinders us" (Spinosa B. "Ethics", Moscow, 1932, p. 141). After all, they are not the realities of the hereafter, they are 'forms' of bio-energy. Man (society) is merely their abode. The idea of good and evil did not emerge from nature. The German philosopher Hegel stated that man is neither good nor evil by his nature, since the laws of human morality are infinitely greater than the laws of nature. If this is true, the new task for psychology is to learn the process of good and evil in man.

Peering into the unreasonable behaviour of intelligent people, though speculatively, I perceived that when this occurs man is obliged to counteract experience with knowledge, awareness with a transformation of this knowledge to an image of spirituality as an inner generator of good. Knowledge, intellect and even willpower are all in the behavioural image, soaking up the history of man to work out social procedures for the solution of everyday goals. An aesthetic image of this includes self, passion, hedonism, eroticism, and egocentrism whose biofeedback is a result of satisfaction and enjoyment of conquest. The instincts are the 'servicing' apparatus of this image. It may be assumed that energy, reflected in the social experience during a life span, is scarcely sufficient to satisfy drives. Hence arises the necessity of additional energy for the accumulation of the Spirit that is in an ethical sphere.

I dare to state that one of the methods to lower psychological stress in people might be the inclusion of a planetary motive in the communication of the spiritual and the material vital functions. The cosmos is the genesis and continuation of the highest intellect. In this lies the transcendental nucleus of the idea of this search for the consciousness language, which will help to obtain from the cosmos the energy fuelling the intellect, however not by thought, but by good

deeds. Our organism contains phagocytes, the cell protectors that devour pathogens. Thus, why should there not exist a cleansing energy helping man to accomplish good deeds. This idea does not seem to be absurd, because some observations and studies of psychic states in space justify pondering over such problems.

As mentioned earlier, far from Earth, the cosmonauts have noted the rush of an unusual, positive energy, a sense of the soul's freedom as never before, also an exceptional awareness of their second 'Ego', a connection to all peoples and mainly a feeling of love for mankind in general. It is remarkable that mainly in space, people recall the past, and realise that inner freedom is life's essence. These facts generate a scientific interest for time and space energy and their transformation into universal awareness.

Physicists know that the current picture of the universe needs to be substantially improved. It is time for us to seriously contemplate the problems of the cosmos, the issues of the living matter, the biofield, the geo-political thinking, and the universal awareness. In following ideas formulated by Soviet psychologist-academician B.F. Lemov about the psychic world of man, we should try to create bio-energy meridians on the earth planet. The naturalist had designed the longitude and latitude of the physical orientation in space for the connection between man and the environment. I think that there are also spiritual meridians in space, which are crossed by spiritual and natural forces creating the vector of generations, and unity of cosmogonic and earthy spirits. 'Little' is left to accomplish but only to study the form of the language to translation out-of-body awareness in an image of the spirit, realising a beneficial inter-human communication. This should have been 'opened' yesterday. The human world is too irrational and cruel, sometimes humiliatingly unreasonable. Despite the fact that on earth all is available for a natural energetic saturation of man, and it lacks the capability to hold the spiritual energy of the vital essence. Mankind is not only incapable to hold it but misconstrues it. It is possible, that the people may have lost the mechanisms for decoding of mind's energy. But if there is a psychical field, a psychic image there should also be a psychic matter. Most probably is concerns energy in the form of information, which is still beyond the limits of our consciousness. I suppose that the deciphering code lies in time, which is not coinciding, with the cycles of earth's life. The causes of this discrepancy are most probably the dissimilarity in the bio-field degrees of the spiritual and the physical infinities. We need a code for the coordination of these fields. We need new psychological and theological paradigms in the interest of spiritual unification. It is a time to become aware of certain worldly wisdoms – the true value of life is measured by the lack of suffering, and not the availability of pleasure (Schopenhauer A. "Freedom of Will and Morality", Moscow, 1992, p. 417).

We should also be aware that the level of the knowledge of the spiritual forces, of the natural genesis, is not found only in the historical space of countries but much farther beyond its limits. Then the scientific in religious consciousness will merge and become the image pulsar of the human subjective world. In this case, the super human image will be the overall planetary mechanism of psychological reverence for life as the highest measure of creativity and death as the beginning of immortality. The image of the world gives us an example of cyclic phases and renewal of universal principal. If we unveil the forces of the spirit we will also learn to control socium in all its potential facets.

All this, will probably be accepted by the reader with some difficulty, but most probably rejected. I have reached and continue to strive for this knowledge slowly, step-by-step. However, what is its relationship to flying safety? I can not justify that you retain my opinion, underlying once more that the problem of flying safety is a human problem, a problem of man's fate and right of choice and life. Man in flight, whatever you might say, is closer to the universe of its knowledge, and we should listen to the soul of the pilot. Of course, there are flyer-specialists, flyer-professionals, but there are also flyers whose spirituality, verbalised in love of flight, enriches their morality, their soul. Probably, they will consider this chapter not as 'abstruse', but as an invitation to a world of high inspiration, where 'Ego' is only the reflection of happiness, a 'swallow' of clear sky (Nonna Oresina).

This book covers past experiences reflecting merely personal viewpoints. I do not lay claim to "truth of the highest level". Once a famous Soviet cosmonaut, former fighter pilot G.T. Beregovoy, gave me his autobiography with the following inscription: "Only through colossal labour and conviction is it possible to acquire the desired perfection, but to describe one's own persuasions is a one hundred times more difficult task".

Writing my book, I sensed the truth of his words. Yes, this is how the life and the labour of aircrews have touched me. As for the scientific facts, investigations – they are all true. As to the lyrical philosophical, sociological diversion and comments, I leave it to the reader to be the judge. I feel some misgivings due to the fact that I could not depict with words, the greatness and beauty of the flyer's soul. But it is impossible. A copy, a model, is always much poorer than the original. A good example follows.

I once knew Alexander Belov, a worker from Nizhny Novgorod. He was a member of the aeroclub as a young chap, and he injured his leg. Forty years passed. Alexander had become a prominent inventor in a field not aviation, but he regularly subscribed to a magazine "Aviation and Cosmonautics". I asked him, why. "You see" – he told me – "if a war were to suddenly erupt and the country would draft flyers. Thus, I should know all about it. Then I will weld a special pedal for my shorter leg, and up I go!" He died recently. Before his death he requested of his colleagues at the shop: "Please, gather at my tomb on August 18, the day of Soviet aviation, and drink a glass of vodka for our flyers". Maybe, in these words there is a much greater meaning in my entire book. Once my five year-old son, when he saw in the sky the exhaust fumes of aircraft he said: "Look dad, it's drawing an aircraft, painting pictures". And today I say: "Young flyers draw your destiny in the sky and let it be much happier than our fate!"

Ponomarenko Vladimir Alexandrovich is a prominent researcher in the field of aerospace medicine, engineering psychology and ergonomics, pedagogical psychology – the founder of a scientific school of investigators of the dangerous professions and preparations of humans to surmounting of extreme psycho-social situations in flight. Jointly with other scholars, he developed the concept of human factors in aviation. Also, he utilised a methodological tool during investigations of flight accidents and statements of their causes. His theory of flight image has been realised in the practice of flight instruction, and elaboration of engineering-psychological specifications to flight display systems, including tactical, navigational, on-board equipment informational presentation, scientific corroboration and experimental confirmation of optimal allocation between human operator functions and functions of automated flight control systems.

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14. Abstract

This book provides insight from a Russian perspective into the psychology of the flyers (pilot and other aircrew members), and their constant struggle to cope with the procedures dictated by ground-based directors while enjoying the thrill and emotional high of flight. The author takes the reader through the turmoil of flight emergencies, unpopular ground-directed missions, and, ultimately, aircraft mishaps. He describes the difficult conditions placed upon the flyers by a system inadequately prepared to address human factor issues, and points out that it is the responsibility of those on the ground to improve the conditions of the flyer. Those improvements can come from knowledge based on research and appreciation of the flyers' mission.

Chapter 1 provides details of the problems associated with aircraft accident investigations and the impact these can have on the flyer's dignity. Chapter 2 describes many of the dangers associated with flight, as well as the skills necessary to overcome those hazards. Chapter 3 describes the current state of human factor issues and flight safety. Chapter 4 deals with ergonomics and their relationship with flight safety. Chapter 5 matches the role of the flight surgeon with the operational requirements of the flyers. Chapter 6 identifies the problems encountered when one is too conservative toward a profession that requires radical, rapid, and sometimes fatal in flight decisions. Chapter 7 explains how the flyer can maintain a healthy body and mind. Chapter 8 summarises the research and lessons learned by the author while working with the flyer and within the establishment.

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